SCIENCE EDUCATION

THE OFFICIAL ORGAN OF

The National Association for Research in Science Teaching
The National Council on Elementary Science
The Association of Science Teachers of the Middle States

VOLUME 29
NUMBER 4

OCTOBER, 1945

Published by Science Education, Incorporated

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INTRODUCING THE CONTRIBUTORS

PALMER O. JOHNSON ("The Scientific Study of Problems in Science Education") is professor of education at the University of Minnesota. Among his responsibilities is that of directing the program for the training of teachers of science. Dr. Johnson's research publications have been largely in the fields of science education, principles of experimental design, and statistics. His most recent contribution to SCIENCE EDUCATION was as editor of the symposium on science education in the post-war period, which appeared in the issues for October and December, 1944.

JAMES E. CASSIDY ("Airships, Leviathans of the Skies") is chief engineer of the United Nations Airships Corporation, and has spent forty-five years in civil, consulting, and military engineering. His interest in aviation, which dates back to 1910 when he learned to pilot an airplane, brought him into close association with the late General "Billy" Mitchell. During the first World War, Colonel Cassidy was Commanding Officer of the Corps of Engineers, First Army, and during the second World War he was Chief of Construction, Army and Navy Munitions Board.

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BETTY LOCKWOOD ("Facts Fight Fears") has taught in the elementary schools and junior and senior high schools of Detroit, and has also served as an instructor in Wayne University. She has done critic teaching and assisted in the training of student teachers at all levels. Miss Lockwood helped in the formulation of the Science Course of Study for Elementary Schools of Detroit and has served on numerous science teachers' committees.

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OREON KEESLAR ("A Survey of Research Studies Dealing with the Elements of Scientific Method as Objectives of Instruction in Science") is at present serving as Officer in Charge of Quarterly Rating Examinations for the Naval Air Training Bases at Pensacola. While on a recent annual leave, Lieutenant Keeslar completed his work for the Ph.D. degree at the University of Michigan.

JOHN S. RICHARDSON is associate professor of education at Miami University, and principal of its laboratory school. For the past nine years he has supervised the practice teaching of the prospective teachers of physical science at the university. With this issue, Dr. Richardson joins the editorial staff of SCIENCE EDUCATION as editor of the Department of Teaching Reports. The first contributors to his department are EWART L. GROVE ("Activities in a High School Greenhouse") and ARTHUR L. ASSUM ("Keeping Up with Science"). Mr. Grove is a graduate of the State Teachers College at St. Cloud, Minnesota, and has the master's degree from the Ohio State University. Mr. Assum, formerly a secondary school teacher, is now an assistant residence counselor at the University of Chicago.

Another change in the editorial staff of the Journal becomes effective with the next issue, when ELSA MARIE MEDER relinquishes the post of associate editor, a move made necessary by the demands of a new position.

SCIENCE EDUCATION

VOLUME 29 OCTOBER, 1945 NUMBER 4

THE SCIENTIFIC STUDY OF PROBLEMS IN SCIENCE EDUCATION

PALMER O. JOHNSON
University of Minnesota

SCIENTIFIC facts may command interest because they are merely used to describe something that has happened or an existing state of affairs. In this respect they may have considerable value in practical matters. But we are seldom satisfied with this use alone. We try to make use of the facts in getting at an understanding of the underlying processes in operation in the situations under study. Furthermore we attempt to infer from such situations for more general ones. In this inductive reasoning we are carrying out part of the process by which new knowledge comes into being. The conclusions normally become more and more valid as more data are gathered.

While it is chiefly in the collection of new experiences that science makes progress, it may also do so by better ordering of the experiences we have had. Experiment is planned acting, governed or guided by the working hypothesis. Progress in science has been accelerated by the imaginative procedure of formulating a directive hypothesis in planning and executing investigations. Briefly the method consists in setting up a tentative hypothesis based on existing knowledge and subjecting it to test by arranging experiments that yield one result if the hypothesis is true and other results if one or more of a number of other admissible hypotheses are correct. In the incipient stages of a new science, there is little or no existing knowledge to form the foundation of a working hypothesis. The patient collection of facts makes up the chief activity. Shortly, however, speculation of the findings begins, and tentative theories are introduced. Then experiments and observations are carried out to test the theories, which are further modified and reformulated as an outcome of the new observations. Thus is set up the recurring cycle of experimental tests taking turns with theoretical speculations. When the history of the science of science education has been written it will likely have undergone similar development.

Just what is the status of science education today? Most of its content is of a theoretical character which has not been brought into union with definite hypotheses. Very little, if any, of our knowledge of science education can be said to have been explained, verified, and generalized in the scientific sense. Perhaps we may say that we have considerable empirical knowledge resulting from the empirical method. The empirical method proceeds on the assumption that since certain results are noted to follow from a certain set of conditions if the same results are wanted again the original set of conditions must be repeated. This method cannot get us very far. It is hazardous and often leads us astray.

It may be well to recall Huxley's definition of the practical man in this connection: "The practical man is the man who practices the errors of his forefathers." What is wanted is the discovery of the necessary and sufficient conditions resulting in an observed phenomenon. Only when we have detailed knowledge of the most probable causes can continued investigations prove fruitful. The main role of science is to analyze the causes of events thereby leading to the formulation of general laws. Scientific knowledge is, therefore, the opposite of empirical knowledge. It should be pointed out, however, that science and empiricism differ mainly in gradations.

If the writer appears to have gone astray from his original assignment by the editor of SCIENCE EDUCATION it is only because he believes that the biggest promise of creating some day a science of science education rests upon the type of training that is given to our future leaders in science education. This training includes the experiences gained in applying the scientific method to the study of problems in science education. Every adviser of graduate students is aware of the obligations and opportunities he has to guide them in their research studies. He is also aware that his influence is likely to be more effective if he displays in his own research the vigorous application of the principles he expounds to his students. While in each institution giving graduate training the contribution from such studies may not loom large, the accumulative effect from all institutions engaged in this work can make substantial additions over a period of years to our knowledge of science education.

A wider diffusion of knowledge of researches recently completed or under way at various institutions would, in the opinion of the writer, be of considerable value to those who are interested in applying the methods of science to the study of problems in science education. It is from this viewpoint that the following resume of a few recent studies carried on by students under the writer's supervision or by him is presented.

Clark [1] carried out an experiment in an attempt to determine what contributions the school excursions might yield in four sixth-grade units, each of which occupied twelve fifty-minute periods and was taught in from five to ten schools at the same time. The four units consisted of (1) Egypt, the excursion for which was to the Egyptian room at the Minneapolis Institute of Arts, (2) Printing, to the plant of a Minneapolis daily newspaper, (3) Transportation, a trip from Minneapolis to St. Paul on the streamlined train, the Hiawatha, and (4) Communication, to the main Minneapolis telephone exchange. Of the total of 375 pupils engaged in the experiment, 182 were boys and 193 girls.

In each unit the same content was presented to both the experimental and the control groups. While the experimental groups went on the excursion, the members of the control groups saw pictures and discussed the same material that the excursion groups saw. The experimental design provided that the control groups received the best possible instruction using the most effective materials available other than the excursion. An additional control designed to provide evidence of the influence of maturation, practice effect, and other possible contributing factors consisted of a sixth-grade group which had no classroom instruction in the content of the unit. This group took all the tests on the same schedule as the participating groups.

An unique feature of the experiment was the provision of the in-service training it provided for the ten participating teachers. The teachers all attended eight study meetings conducted on a workshop basis, which provided opportunity to develop the scientific attitude and to provide teacher training in the techniques of presenting

units effectively in both control and experimental situations. Each teacher kept a detailed diary account of the exact procedures she followed and also recorded children's reactions to the unit. Teachers and schools were rotated so that a teacher who taught an experimental unit first would next teach a control unit, and vice versa.

Achievement tests based on the objectives set up for each unit were developed and perfected over a three year period previous to the experiment. The tests were administered before and after the two-week unit and were repeated four weeks later to test retention. An interest test was also developed for the purpose of determining whether or not changes in interest occurred in connection with each unit. The voluntary reactions of pupils to the excursion were also secured by having each participant write an account of his interests and likes or dislikes based on the experiences gained in the unit. Another valuable aspect of the study was the preliminary trial of the experimental design in three separate Minnesota schools.

The Johnson-Neyman method of statistical analysis was applied to the experimental observations. This method of analysis makes it possible to determine the relative efficacy of the educational factors under comparison using all the cases and making allowances for inequalities in the experimental and control groups with respect to basic characters of matching. In this investigation pretest scores and mental ages were the basic characters used. Socio-economic status was also controlled. Furthermore, if the one method is superior for bright students, for instance, but the two methods are equally effective for other pupils, this fact is established by the nature of the region of significance.

The museum type of excursion was the only one of the four excursions in which a significant difference was found in favor of the control group, that is, the group which did not take the excursion. In the Printing, Transportation, and Communication units a significant difference in mean achievement was found for the excursion groups. In the unit on Transportation a significant difference in favor of the experimental group was found only for the boys.

Hoyt [2] made contributions to mathematical statistics and to our understanding of the factors underlying achievement in college physics. Only the latter will be discussed here. The Department of Physics of the University of Minnesota offers three well-defined beginning courses: (1) Physics 1-2-3 is offered to students in certain liberal arts curricula which do not require college mathematics, (2) Physics 4-5-6 for students taking pre-medical training, has higher algebra and trigonometry as prerequisites, and (3) Physics 7-8-9 is offered for engineering students and for majors in physics in the Arts College; for this course students must either have taken calculus or be taking it concurrently. One of the questions to which an answer was sought was: What are the relative contributions of general intelligence, general scholastic achievement, and specific proficiency in mathematics to achievement in college physics, and are the contributions of these three factors quantitatively different in the three different classes of college physics? One year was spent in the development of the necessary measurement instruments and in the design of the investigation. In the final study, 668 students were enrolled. The method of analysis was that involved in the testing of linear hypothesis and in setting up regions of significance.

Only one of the principal findings can be presented here, that is, a significant relation between achievement in physics and proficiency in mathematics was established. The manner of analysis resulting in the finding is worthy of attention. It was found that there was no significant variation among the three instructional groups with respect to the means of achievement

scores when linear adjustments were made for the regression of the physics test scores on the three independent variables, proficiency in mathematics, psychological test scores, and honor-point ratios computed on the basis of the college grade earned by these students during the year immediately preceding the year of the study. When the achievement test scores were adjusted for their regression on psychological test scores and on honor-point ratios, the variation among the means of the instructional groups was found to be significant. This showed that the dependence of the physics scores on those of the mathematics test was significant.

Peterson [3] compared the achievement of students in an integrated course in physics and chemistry over a one year period with the achievement of students in conventional courses of one year's duration in physics and in chemistry. Approximately five years were devoted to the preparation of the fused course in physics and chemistry and in the construction of the evaluation instruments. Carried on at first as a self-contained experiment in the University of Minnesota High School, the final investigation included experimental comparisons in twelve cooperating schools. In addition eleven other schools contributed to some portions of the study. Approximately one thousand students were enrolled in the investigation.

The relation to achievement of such factors as mental ability, chronological age, sex, year in school, years of science, years of mathematics, previous science courses, grades in school, grades in science, pretest scores and the like was studied to determine those which could be used as the most rigorous controls. Mental ability and chronological age were selected as the basis of maintaining comparability between classes. The Johnson-Neyman method of analysis was employed, thus making it possible to plot the areas of significance which define those portions of the population for which it is permissible to generalize from the data of the various experiments.

The achievement of the students in the experimental course, the Fusion of Physics and Chemistry, was compared with that of students with the following preparations: (1) one year of physics, (2) one year of chemistry, (3) one year of senior science, (4) one year of physics preceded by one year of chemistry, and (5) one year of chemistry preceded by one year of physics. In all these comparisons the mean achievement of the students in the fused course was significantly higher except in the case of the group who had had a year of physics followed by a year of chemistry. Adjustment in the means for inequalities in mental age and chronological age was made in all the comparisons.

Johnson [4] evaluated laboratory practices in zoology. In the biological sciences it is customary to require carefully prepared, detailed drawings by students in the laboratory under the assumption that this activity is fundamental to an understanding of plant and animal structures and functions and that the character of the drawings is an index of laboratory accomplishment. The time spent by students in making acceptable drawings and by the instructors in grading drawing plates constitute a very considerable proportion of the total time and energy of both groups.

The Department of Zoology of the University of Minnesota had long felt the need for a revision of the laboratory procedures in general zoology. Detailed drawings were required from the students and these drawings formed the basis upon which the laboratory grades of the students were determined. The writer was asked by the chairman of the department to design and execute an experimental evaluation of their practices. A number of meetings were held with the staff to obtain from them clear formulations of the objectives of general zoology and suggestions for changes in

their procedures that might be desirable. During the previous three-year period the writer had cooperated with the staff in the development of comprehensive examinations so that dependable measuring instruments were available for the experiment.

For the first year of the experiment the entering group of students was subjected to the usual procedures. Systematic observation and evaluations were made over the year period. The group of students enrolling in the following year was not required to make the detailed drawings and it was announced that their laboratory grade would be determined by the written and practical examinations. It was provided that the greater portion of each laboratory period was spent in studying the material and a minimum of time in drawing. It was suggested that the student make quick sketches of various aspects of his own and of the demonstration material. The instructor was charged to correct any misconceptions which might occur as revealed by the student's work.

Much care and ingenuity had been expended in developing the practical examinations for the laboratory objectives and in working out efficient methods of administration. This was also true for the comprehensive written examinations which were designed to measure the extent to which the student had acquired the fundamental facts and principles and the ability to apply them in interpretative and problem situations. The complete evaluation program included other periodic written and practical examinations but the critical comparisons were based on the so-called lecture-comprehensive and laboratory-comprehensive examinations. The same measurements were made on all students in the control and experimental groups over the two-year period. There were 456 students in the former and 433 in the latter, for whom all observational and evaluation data were complete.

The Johnson-Neyman method of analysis was applied to the data. College aptitude test ratings and high school achievement ratings were the basic characters of matching.

From the findings of the investigation it may be inferred that students pursuing zoology under the new plan, in so far as they may be representative of the groups constituting the subjects of this investigation, may be expected to do at least equally well if not better ($P<.09$) in achieving the outcomes as measured by the lecture-examination and that with respect to the achievement of the laboratory outcomes as measured by the laboratory examination, they may be expected to do better ($P<.01$) than under the old plan where emphasis was placed on detailed laboratory drawings. Furthermore, the reactions of students as well as of instructors indicate a liking for the new procedure. The students have more time to study their materials and good students with little drawing ability are no longer penalized by their inability to make polished drawings in a course where this outcome does not loom large as an important outcome of instruction. The considerable burden of grading and correcting drawing plates has been lifted from the instructors thereby saving time for their more significant functions.

In concluding, the writer wishes to point out that the newer types of experimental design and the correspondingly appropriate statistical analysis offer new promise for the scientific study of educational problems of the kind reported in this paper. Modern ideas of experimentation differ sharply from traditional ones. The traditional experimenter follows the doctrinaire theory that an experiment must be simple and emphasizes the importance "of varying the essential conditions *only one at a time.*" The modern experimenter believes in combining several lines of inquiry in the same experiment thereby increasing its efficiency and comprehensiveness [5, 6].

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COOPERATION FOR EROSION CONTROL

P. ALSTON WARING

New Hope, Pennsylvania

IN 1939 my closest neighbors and I, five farmers living on a small, upland creek in southeast Pennsylvania, began a reorganization of our crop land for erosion control which has resulted not only in a redesign of the field areas on our farms, but in a total over-all plan for building a system of permanent agriculture. The plan, of course, was not made in complete form at any one time, but grew and developed quite naturally during the succeeding years out of our experience and a good deal of trial and error.

We five farm families had lived on adjoining land for years and between us existed the usual bonds found in a rural community. Perhaps, therefore, the most significant thing that we learned as we got into this project of soil conservation was the extent to which the small stream which ran through our farms influenced our land and therefore our lives and futures. In time we were to see that here was a bond of very real importance, a new type of region which was neither primarily economic or political, but defined by topography.

Honey Hollow Creek is an upland tributary of one of the larger streams that eventually flow into the Delaware River. It drains a tiny area of farm land. We discovered the boundary line of its watershed as we developed our project for erosion control, and this was a discovery of very real importance. In the past we had thought of the boundaries of our farms as setting us off from one another and defining our spheres of work. The watershed boundary, however, was something new in our experience. It indicated that we had much in common and that our destinies were linked together in a very real and tangible way, more tangible than we had suspected. The discovery made it obvious that erosion on my farm had been caused by conditions on the farms above me on the watershed, and that I was determining conditions on the land of my neighbors below. If we were to solve anything we must solve it together. We could not escape the influences of the slopes we lived upon and the stream which had made the slopes.

How a problem was attacked

At this point there began a revolution in our thinking about ourselves and our work as farmers, and about our relationships to one another. As we have gone on from this early experience in land use, and have observed the development of such larger river valley planning as in the Tennessee Valley, we have come to understand better the importance of this kind of regional approach to the economic and social life of the community.

Our experience, however, has taught us other things as well, though all of them may be said to stem from this fundamentally new concept of the influence of the topography, the slope and the stream, over the lives of farmers. We five families in the Honey Hollow Creek area are dairymen and poultrymen and general farmers. We follow the usual pattern of agriculture in our countryside, raising grain and hay and pasture for our stock, and in general practicing a reasonable balance of field cropping and animal husbandry. It is an old farming region, many of the houses having date stones which indicate that they were built in colonial times, and some of them in the decades immediately following the arrival of William Penn. It would be fair to say that the farming has been good farming, for animal husbandry has been coupled with field cropping, pasture and hay have been grown, and there has not been an excessive use of row crops as in the regions of one-crop culture.

But in spite of this the survey made by the Soil Conservation Service at the beginning of our project indicated that there was very decided erosion of much of our soil. On some fields the topsoil loss was discovered to be as great as 75 per cent, and this mostly from sheet erosion. There were gullies, to be sure, but these symbols of soil depletion were not a chief characteristic of our farms.

This discovery came as a surprise to all of us. For though we had known that yields had lessened over the years and that erosion was present, the extent to which our land was depleted was certainly not understood. Perhaps we would have gone on indefinitely in our ignorance of the problem had not the erosion resulted in the silting in of a low land area and in the causing of floods. These became serious enough on my farm for me to call in the Soil Conservation Service for advice. It was from this Service that we learned the watershed nature of our erosion problem, and from it we had the encouragement and technical advice which started us on our small cooperative land-use planning project.

We began slowly to use maps which resulted from a soil and erosion survey, and with each man working on his own land, we have in time completed the redesign of our field lay-outs, converting the old square field pattern to contoured strip fields with terraces in some areas where the conditions warranted them. Besides this new arrangement of fields we have rethought our rotations, and are using more hay and grass land than formerly and planting more cover crops for winter. The contoured strips are in general one hundred feet wide. We plant them alternately in spring and fall so that no large area is opened to a seed bed at one season. For all conservation techniques, of which there are many, have as one of their primary functions the checking of run-off and the holding of water on the land.

Recently, too, some of us have been experimenting with a trash mulch seed bed, harrowing the crop residues into the topsoil instead of plowing. Though this has not been practiced for a long enough time to show conclusive results, we believe that it has added to our control and is a practice which may help in the total problem of conservation.

Today, some six years after we began, our whole small watershed of some 850 acres presents a new appearance, the fields

curving about the slopes and the crops alternating in a new pattern and new design. We were laughed at, of course, for breaking with tradition, but we persisted, and today contoured fields are beginning to appear here and there on our neighbors' land as the idea spreads and is accepted by those who have observed some of the practical results of the work. This edging out of conservation practices from the spots where it is being started throughout the country is, of course, a familiar characteristic. And conservation practices of many and varied types are appearing across the face of America. We are told that it is usually begun on single farms and perhaps moves thus into a neighborhood. The interesting aspect of our Honey Hollow work is its small watershed character. In very few cases has conservation been undertaken on a total watershed basis at one time and the work mapped and planned as a unit. This gives the Honey Hollow Creek watershed some degree of uniqueness in the present movement toward a permanent agriculture.

At the end of the fourth year we came to the conclusion that since we had had some success in cooperating in our plan for a redesign of our crop land to check erosion, perhaps now we could extend our project to include a plan for development of continuous cover for bird life which would connect our wood lots and break up the large areas of cropland. Here again the Soil Conservation Service aided with technical advice, and one of us made a map to visualize the problem. We have now a clear cut program for establishing a system of berry-bearing hedge, roadside, woods-edge plantings over the entire watershed. It is an ambitious plan and with the limited labor at our disposal it will no doubt take some years to establish. But the plan is there and we have a clear objective toward which to work. In time we hope to achieve it, and in time, too, we hope to evolve a plan for the better care and conservation of our woods areas through a program of better forestation.

SOME RESULTS OF THE PROGRAM

On the technical and scientific side we farmers have learned a number of important things as we have worked on our project in the Honey Hollow Creek watershed. We have learned, first of all, how extensive and severe is the erosion of soils on agricultural land, even in well-farmed countrysides. We have learned how dangerous are flash rains, such as the great thunder-storms to which we are subjected so often in summer, and how important it is to be prepared for them by as many devices as possible to hold the soil where it belongs.

Second, we have learned that the fertility of soils can be rebuilt when erosion is checked, and that a system of permanent agriculture can and should be established to take the place of the impermanent and soil-depleting practices which are so extensively employed by American farmers. We are convinced that a living can be gained from the soil without mining it, and that fertility can be increased and the water table can be maintained at a desirable level. We also know that it is well for farmers to understand more about soils. Soils differ greatly even on a single farm, and they vary in their tendencies toward erosion and their capacity to yield crops.

We have not been working at our project for a sufficient number of years to offer exact, scientific conclusions as to increased yields per acre as a direct result of the work we have done. But in the last two years we have all reported better yields, though this may be the result of a number and combination of contributing causes. One of us says that he regards his yields as 20 per cent improved. This is not determined by measurement but mainly by general observation, but it is interesting because the per cent of increase conforms

to the figure used by the Soil Conservation Service as a result of observations over a period of six to seven years of farms doing conservation work in all parts of the county.

Furthermore, our springs have not gone dry, even in the severe drought year 1944, whereas formerly some of them had dried under far less severe a test. This is a decidedly accurate observation of results and we are convinced that our efforts to hold the water and cut down run-off from our fields has raised the water table in the watershed.

We have learned facts about machinery, too, in its application to conservation practices. This is important, for as we move into a changed system of agriculture farmers will need tools of different design. Most planting tools are made today for clean tillage. But if experiments in the working of residues into the topsoil prove successful it will be necessary to change the design of many accepted tools to increase the efficiency of conservation work. In regard to the larger machines, we have learned that the combine and the pick-up baler can operate easily on contoured strips of hundred-foot widths, which was thought to be impossible, and that it takes less power, as indicated by gas consumption, to work on the level of a contoured field than up and down grade on the old square arrangement.

We have learned the value of ponds in the total plan for stream areas, and the importance of continuous cover if a balanced wild life is to be encouraged.

In the realm of community relations, certainly our experiment in land-use planning on a small watershed basis has taught us that the stream is a common bond between neighboring farmers and that cooperation can be achieved in planning a system of permanent agriculture. Moreover, I think we have come to realize that though conservation starts with the practical business of stopping run-off and devising suitable practices for each field in the fight against erosion, in the end it is more than these. Conservation has to do with apprehending more clearly the eternal relationships of soil, rain, sun, man, and all the works of man. It has to do with food and food with fertility, and these with health and better living for people. There is a widespread movement in America among farmers and non-farmers alike which is adding a new and needed leaven to general education. It is concerned with the building of an improved groundline husbandry in the United States and it may have important results in more secure and better living for people in all communities both urban and rural. We five farmers on Honey Hollow Creek have caught a glimpse of this, and although we have made but a beginning we believe we are in line with an important trend.

FACTS FIGHT FEARS

A HIGH SCHOOL EXPERIMENTAL PROJECT ON INFANTILE PARALYSIS

BETTY LOCKWOOD

Redford High School, Detroit, Michigan

INFANTILE paralysis is one of the most feared diseases of today, feared by communities, by parents and by children. When one or two cases appear within a community, the whole populace becomes alarmed. Rumors fly thick and fast: "Be careful of your milk supply;" "Better to keep the children out of school;" "Beware of food supplies;" "Don't go swimming." Parents remove their children from the city to the country and take the utmost precautions. Suddenly, some family that has been very particular about its health rules finds one of its members stricken. "What can we do to avoid the disease?" and "What do we know about infantile paralysis?" are questions heard from all sides. Newspapers add to the consternation with pictures of crippled patients. Finally, the morale of the town or city is weakened through fear and sometimes panic.

It was to help answer questions such as these that an experimental educational study was started in Detroit in June, 1944.*

Detroit was a logical place because of its great urban area, because of its great gathering of people from all over the country, and because every few years an outbreak of poliomyelitis occurs, causing panic and often delaying the opening of schools in the fall.

When the study was planned in the spring of 1944, no one could predict that the very summer of 1944 would bring an outbreak of infantile paralysis, not only in Detroit, but in various sections of the country. No one could predict that the opening of the Detroit schools would be delayed because there were nearly 300 cases within the city at the time set. Considering the total population of Detroit, however, this meant only one case to about every 5,000 persons. Many physicians and health authorities believed that it would prove far better to keep the children in their accustomed groups and that it was not necessary to postpone the opening of schools. Nevertheless, public opinion demanded postponement, mainly because of general fear aroused by passing comment and lack of knowledge concerning the disease.

* The study was initiated by The National Foundation for Infantile Paralysis, which sought the cooperation of Dr. Warren E. Bow, Superintendent of the Detroit Public Schools. A sponsoring committee was appointed, composed of:

Manley E. Irwin (Chairman), Supervising Director, Division of Instruction of the Detroit Board of Education.

Vaughn S. Blanchard, Divisional Director of Health Education of the Detroit Board of Education.

Garner M. Byington, M.D., Dr.P.H., Director Child Welfare and School Health Service, Department of Health of Detroit.

Emil L. Massey, Director of Senior High School Sciences of the Detroit Board of Education.

C. Louis Thiele, Divisional Director of Exact Science of the Detroit Board of Education.

Donald M. D. Thurber, Michigan State Representative of The National Foundation for Infantile Paralysis.

Grace F. Woolfenden, Supervising Principal, Oakman School for Crippled Children, Detroit.

Miss Betty Lockwood, a biology teacher at the Redford High School, was selected to organize and present material on the virus diseases with emphasis upon infantile paralysis in connection with the study of other communicable diseases to several tenth grade biology classes. The entire project was guided by S. D. Kramer, M.D., Epidemiologist at Michigan State Department of Health.

Despite the fact that children are the ones most affected by infantile paralysis, schools and textbooks offer little or no information relating to this disease. Listening to the rumors current among their parents, children acquire an abnormal fear, which is quickly passed on to others of their age. How can this be corrected?

Since the students of high-school age today represent our citizens and parents of tomorrow, they seemed the logical age group with which to start. If they could become acquainted with the known facts concerning infantile paralysis, within a few years there would result a community intelligently respectful of this dreaded illness. Such a community would not give way to undue alarm and disturbing rumors.

It was natural that the study of infantile paralysis should be made a part of the biology course, since that course contained material on health and disease. However, when the standard biology textbooks of the high school were examined, they were found to contain little or no information concerning infantile paralysis. In fact, very little information could be found in textbooks on any level. Therefore, it became necessary first to gather factual material concerning the history, the symptoms, the different types of the disease, the modern methods and resources in combatting it, and the research being carried on throughout the country. This material was developed in a usable classroom form as a printed, illustrated booklet.

INTRODUCING THE STUDY

The material developed for this study was presented to approximately one hundred tenth-grade students in three classes as a part of the larger study of communicable diseases caused by viruses. Specifically, it was introduced after a general discussion on viruses in the following manner:

> There may be many diseases caused by viruses. We already know facts concerning a few of them. One that we have heard much about this past summer and fall is infantile paralysis, or poliomyelitis, as the doctors and nurses call it. This is a disease in which there is a great deal of public interest and about which there still remains much to be learned. When a number of cases appear within a community the people usually become frightened, partly because of fear of the disease and partly because of comments and rumors that pass from person to person. Some of these comments are truth, others are not. Many of them cause needless worry, mainly because the average person knows so little concerning the disease.

A series of statements about poliomyelitis which are generally believed by the public was used as an immediate starting point. These were checked by the students as true or not true, depending upon their personal belief. No attempt was made to correct or check these reactions to the statements, they were used mainly for the purpose of stimulation. However, the responses were kept and rechecked after the study of the disease had been completed.

THE CLASS WORK

The information gathered in booklet form was used as text assignments and was the basis for class discussions. The students showed great interest in the study of poliomyelitis and asked many worthwhile questions, such as:

> If the virus can enter through the wound left by a tonsillectomy, can't the virus get in through any wound that exposes nerve endings?
>
> Why does the disease affect only a certain part of the body?
>
> Can the virus attack a neuron in the middle or does it have to enter through the dendrites?
>
> Does the virus ever attack the optic nerve, causing a person to become blind?
>
> Could flies carry the virus, and get it on food that people eat?
>
> How does the virus get from the intestinal region to the central nervous system?
>
> How does the virus winter over?
>
> When a person dies from polio, what part of his body is affected?
>
> Why do epidemics usually take place in the late summer and fall?
>
> What makes the arms and legs shrivel after paralytic polio?
>
> I read somewhere that it was just a theory that overexertion was a factor in causing polio, that it was really due to excessive perspiration.

Could it be that the virus gets in through the pores when they are open?

Nerves have been grafted in some of the war-time casualties. Could nerve grafting be used to replant the destroyed ganglia in polios?

A part of the classroom time was devoted to a laboratory period. Various illustrative charts and posters prepared for the study were on display. Summary charts reemphasizing the salient points of the booklet and incidence charts of common communicable diseases were likewise on the wall. Many references from magazines and newspapers were available as well as booklets and materials from The National Foundation for Infantile Paralysis. The accompanying photograph shows the interior of the classroom in which this work was done.

Slides prepared by the Michigan State Department of Health were used. These showed normal nerve cells and diseased nerve cells in various stages of injury. Illustrations were made on the blackboard to demonstrate these stages and to aid the student in recognition of them. Cards were also placed beside each microscope, calling attention to a particular section and to the stage of injury illustrated. The students then used other similar slides to see whether they could identify the various stages of impairment. These slides have since been converted into 2" x 2" film slides and are available on a loan basis to other schools.*

As a summary of their laboratory period the students completed a workbook type of exercise. Included in the exercises were statistics to illustrate incidence of poliomyelitis as compared with other communicable diseases.

EVALUATION OF THE WORK

The work was concluded with a test prepared especially to measure the value of the materials covered in this unit. Following the test, the question was asked, "Do you consider that infantile paralysis is a disease to be greatly feared by you? Why or why not?" The answers to this question were particularly interesting. Some of the comments follow.

Since studying about polio, I do not have as great a fear of it as I did before. I know now that it isn't as prevalent as other diseases which are common such as mumps, measles, etc. I would still worry about getting it during an epidemic, but I am also afraid of scarlet fever and smallpox. Before we talked about it in class, I thought that a person was always paralyzed if he had infantile paralysis.

Paralysis scares me. When epidemics occur, my parents immediately become frightened and we stay away from the city. Naturally with everyone in my family scared and always talking about it, I became dreadfully frightened. Everyone harps on the subject of polio, the newspapers, the radio, the movies, friends. I think they try to frighten people purposely. The pictures in the magazines are always those of paralytic cases. I never knew there were any milder forms until now.

I do not fear it as much as I used to, but I still realize its seriousness.

I think one should have some fear for all diseases. Polio is a disease where the death rate is not high and I know that I haven't much chance of dying from it, but one is never the same after having had any disease.

These answers showed that facts had replaced hearsay. Although no direct effort had been made to have students drop their fear of infantile paralysis, it was very evident that they had acquired a more wholesome attitude towards the disease.

Another result of this experimental study was the knowledge gained by the students as to the resources available to all who need them through the National Foundation and its three thousand chapters. Few students had realized the part that the "March of Dimes" plays in the lives of those afflicted with infantile paralysis. This information plus a knowledge of the symptoms of the disease and a knowledge of what to do during outbreaks will be of benefit in any community.

* The film slides, the booklet used in this study, and a teacher's guide may be obtained from The National Foundation for Infantile Paralysis, 120 Broadway, New York 5, New York.

Comments of parents, as brought back to school by the students, showed that they heartily approved of the purpose of the study. The students likewise seemed to appreciate the added knowledge and recommended that it be made available to other biology students.

This preliminary study would seem to indicate that a study of a particular disease, such as infantile paralysis, is decidedly worthwhile. In this case, knowledge was increased and fear allayed. Moreover, increased respect for the problems and for the research connected with all studies relating to health and disease was apparent.

It would be beneficial from both the teaching viewpoint and from that of students' knowledge if similar material were made available on other diseases. The already crowded textbooks are obviously unable to present current source materials. The public also would benefit by having such facts placed in the hands of its youth.

RECENT DEVELOPMENTS IN SCIENCE EDUCATION AT A STATE TEACHERS COLLEGE

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THIS article is primarily concerned with giving brief descriptions of changes in the courses offered by the science department of the State Teachers College at Trenton, New Jersey. These changes, of course, reflect changes in the philosophy directing the work in science education.

ASTRONOMY AND GEOLOGY

For several years the department has been experimenting with variations of the survey type of course for freshmen. As a result of a poll of opinion of both students and faculty we are gradually moving toward the elimination of this type of course. Starting in September, 1945 those students who are preparing to become teachers of academic subjects at the secondary-school level will take a one-semester course in descriptive astronomy and another in geology during their freshman year in place of the survey course previously offered. Although it is recognized that these are not usually considered freshman subjects it is believed that they will have much to offer toward a better understanding and appreciation of courses in other departments, such as history and geography. As they are subjects which are relatively new to most freshmen, they will be approached with greater interest. They should serve to enrich the student's knowledge of his environment and at the same time present an intellectual challenge because of their newness to him. These will both be laboratory courses, and considerable attention will be paid to scientific attitudes and method. It is our belief that it is desirable to start intensive study as soon as is possible. However, a modified form of the survey course will be retained temporarily for students preparing for other than secondary-school teaching.

REQUIREMENTS FOR A SCIENCE MAJOR

We have gradually been increasing the number of semester hours in science and mathematics for science majors. As now set up a student preparing to teach science will complete forty-five semester hours of science subject matter and one and a half semester hours of science methods prior to graduation. The science courses embrace several areas. Seventeen semester hours are required in the biological sciences, twenty semester hours in the areas of physics and chemistry, and eight semester hours in the earth sciences and astronomy. In addition to the foregoing each student will have completed twenty-five semester hours of mathematics. An attempt has been made to see that the content of these courses is such that it will not only be functional in helping the student to understand his environment, but it will provide him with an adequate background for teaching at the junior or senior high school level. Most of our students start their teaching careers in junior high schools or in small senior high schools where they must teach several sciences as well as mathematics or some other subject.

Although only one and a half semester hours of methods are indicated above, each student actually receives much more instruction in science methods than this. Considerable emphasis is placed on methods within the science subject-matter courses. In addition, there is a rather close integration between the subject-matter departments of the college and the education department. One illustration of this is the

practicum period which occurs in the junior year. As a part of one of the education courses each student spends two weeks in the demonstration school. Here he does his first student teaching. The heads of the subject-matter departments work in close cooperation with the members of the education department in evaluating the lessons taught. In the senior year each student does nine weeks of responsible teaching in a public school of the state. Here again each department head observes several lessons on at least two occasions and discusses his observations with the student and later with the head of the secondary curriculum in the education department.

Emphasis on first-hand experiences

The past several years have seen increasing emphasis on laboratory and field work. It has been found that too many students can recite glibly from the pages of their notes or a textbook but cannot recognize the subject in question when it is seen in the field or laboratory. Laboratory and field work are also believed to be most effective means for developing attitudes and skills associated with scientific methods of problem solving. The science courses have all been revised within the past two years and provision has been made in each course for a maximum of first-hand experiences by the student. Extensive use is made of the 185 acres of our campus, which include a woodlot, two small lakes, and a stream. For more distant trips the college bus is available and is used extensively by the science department. To improve the quality of instruction the administration has wisely recognized the necessity of small sections for laboratory and field work, and now all such sections have a maximum of twenty students.

We have recently improved our provisions for individual laboratory work to the extent that the department now has six well-equipped rooms, each of which can be used for individual laboratory work in a particular area of subject matter. There is also a museum room and a supply room.

For four years the writer has accompanied six carefully selected students to a ten-day institute in Camping and Outdoor Education, held at National Camp, Sussex County, New Jersey. This institute is sponsored annually by Life Camps, Inc., the various state teachers colleges of New Jersey and New York, and the State Departments of Education of these states. So successful have these institutes been in pointing the way to a wider use of the out-of-doors in all branches of the curriculum, and particularly in the field of science, that a committee has been organized at Trenton State Teachers College to explore the possibilities of securing a tract of land for a college camp. It is the thought of the committee that each student would spend at least one month during the four-year college session at this camp. An experimental day camp for pupils of the demonstration school, nine to thirteen years of age, has already been established on the college campus and has completed its second year of operation. Science plays a large part in the evolving curriculum of this camp and it will undoubtedly play an important role in the curriculum of the outdoor education program proposed for the college students. Many of the subjects now taught in the classroom will acquire new and richer meanings when they are taught in the out-of-doors where the student can observe phenomena more intimately and over a longer period of time than is possible in the laboratory periods as now set up. Real science education demands a blending of first-hand experiences in the out-of-doors with further study in the laboratory and library. Any program neglecting any one of these is likely to be incomplete and to give an erroneous conception of the subject.

The foregoing illustrations of recent de-

velopments in science education at the Trenton State Teachers College indicate a few of the major trends in our thinking. There are many problems which have not yet been solved and which in our judgment, are very important. One of these is how to encourage and to select students to major in the science department. At present too few of the students who do superior work in science at the high school level find their way to the science departments of the teachers colleges.

EXPLANATIONS OF NATURAL PHENOMENA BY ADULTS, II*

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Queens College, Flushing, New York

DEMONSTRATION NO. 5. WOOD AND STEEL BALLS

"Here are two spheres [one of wood, 7.1 grams and one of steel, 65.2 grams, same size, about 1 inch in diameter; let subject handle them; then investigator holds one up in each hand]. What will happen if I drop them at the very same time?"

Predictions: Thirteen (correctly) that they will hit at the same time; six of them qualified, "I think," "my guess," "I'm not sure," "I assume," "faint recollection," "just about." Two, "If they fall a sufficient distance, they'll hit together; here the heavy one will strike first." One, "In a vacuum, both together; in this room, the heavy one first." Three at first said they'd hit together, then added, "Now maybe the steel one will fall faster." One, "Steel ball probably a fraction of a second sooner: in high school physics, they fall together, which actually they do not." And 15, that the metal ball will reach the floor first; several with provisos and expressions of caution: "In this case," "I should think," "I'm guessing, of course," "I suppose I'm wrong," "You would expect."

The following tabulation of comments may be interesting:

Mentioned similarity to first experiment	3
Mentioned Galileo	2
Mentioned both Galileo and Tower of Pisa	2
Mentioned Tower of Pisa (one with, "I've forgotten who or what.")	2
"Someone did that from a tower—was it Bologna?"	1
"I think I've seen that done in a vacuum"	1
Mentioned feather and lead in a vacuum	1
". . . to use Newton's language"	1

That only three commented on the similarity to the previous experiment (No. 1, Two Sheets of Paper) seems to be rather strange.

In explaining the prediction that both would fall together, three subjects stated that surface area and thus air resistance are the same, but each added weakening clauses: "Gravity pull is the same. Now maybe the steel will fall faster." "Rate of speed of falling objects has nothing to do with weight." "In a vacuum, they'd drop at the same speed—here they ought to hit at the same time." Two mentioned only area; three, air resistance alone; another, "because they are the same shape." Three referred to weight: "By what I remember, it has more to do with gravitation than with their weight." "The heavier has the greater attraction to earth." "Weight has nothing to do with it." And four really offer no explanation at all. "It's the Law of Falling Bodies—isn't that the idea?—leaning out of Tower of Pisa." "I'm mixed up entirely—resistance is equalized." "There, I'm afraid I have no intelligent

*This is a continuation of the paper by Dr. Oakes which appeared in SCIENCE EDUCATION for April-May, 1945. The bibliography at the end of this part of the article refers to both sections.

explanation: I know or think I know that weight is not a factor in falling." "I just know—couldn't say why."

Of those predicting the steel ball would hit first, nine referred to weight or gravity, including: "So far as gravity is concerned they'd fall at same speed, but friction of air naturally acts more on lighter one." "Greater attraction of earth for heavier one in ordinary atmosphere; in a frightful wind, wooden one will be blown away." "Pull of gravity is greater; it should strike floor first." "I should think that pull of gravity will be greater—now I suppose they'll both hit together!" Three others referred to "resistance": "It is heavier and therefore offers more resistance to air." "Iron ball is more resistant to air." "It overcomes resistance more rapidly than lighter ball." When asked by investigator, "Resistance to what?" the reply was, "I don't know." Three referred to density or mass: "Its density is greater." "Greater mass and density." "Mass should have some influence on speed." Another, "Because of air currents through which they pass." And three others: "It just seems sensible to me." "I think in my common everyday experience, heavy articles seem to fall faster than light ones." "I should know why. [Pause.] I just can't think of a reason for it."

After balls were dropped, statement of observation was called for: 22 (correctly) stated that they strike floor at same time, including: "Humph, exactly the same." "They fall together, don't they?" "I was right." "Well, gravitation works the same on both." Thirteen, after demonstration was repeated one to four times, were more or less uncertain: "About the same, I'd say." "I believe steel one is faster." "I couldn't tell; were they simultaneous?" "Wooden one first. No, both together." "I was right. [Demonstration repeated twice.] Seems to me I was wrong; they fall together." "Looked to me as though iron ball hit first. [Repeated.] Guess not." "Seems to be together. [Repeated.] I'm not convinced but that the heavier one is a little faster." "I still feel heavier one fell faster, but it's very close. [Repeated demonstration.] Maybe the wooden one hit first, but I couldn't swear to it; maybe my eyes aren't good."

Then when asked, "How do you account for what you saw?" one said, "Air resistance is equal; both pull of gravity and resistance to gravity vary with mass." Altogether 12 gave approximately this same answer, i.e., "Both being of same area, meet same resistance of the air." (As noted above, three mentioned similarity to demonstration with sheets of paper.) Another put it, "It's the surface not the air that counts." In all, 17 gave various indefinite replies: "Both must be heavy enough to go through whatever air currents there are." "I guess weight has nothing to do with it—size and shape do—both being equal." "It must be volume of air displaced rather than weight that governs rate of descent." "By what I remember, it has more to do with gravitation than with weight." "The heavier has the greater attraction to the earth." "Friction of the air naturally acts more on lighter one." "Since they are both the same shape, there's nothing to keep either from going through the air at same rate." "Each body is certain weight and has certain resistance to overcome. ["Resistance to what?"] The weight of the air—gravity—I presume." "I think distance was not great enough for law to operate." "Yet from practical experience we know a light object will not fall so fast; at greater height the atmosphere would affect it in some way so it wouldn't fall exactly in a straight line." "It can't be volume: it must be surface area." "There are two elements involved: size and weight." "Well, gravitation works the same on both of them." "My observation [conclusion] then is that weight doesn't seem to have anything to do with falling." And five

who gave no explanation: "If I'd known [explanation], I'd know before they'd go the same." "I memorized the law once—it's tied up with gravity—I don't remember." Or simply, "I can't account for it."

DEMONSTRATION NO. 6. CARTESIAN DIVER

This familiar apparatus involves three elementary principles: Archimedes' Principle (law of floating bodies), Pascal's Law (pressure in liquids), and Boyle's Law (compressibility of gases).

Various comments concerning recognition by the subjects, both when asked at the beginning, "Are you familiar with this experiment," and on the further questions, may be quoted:

"It's the Cartesian diver."

"That may be the Cartesian diver, I don't know."

"I remember a piece of apparatus in Physics called a Cartesian devil which this suggests; in that the object floated."

"Used to have a little man in there."

"That's the thing that goes up and down; I saw a man on the street doing that."

"I saw one on Forty-Second Street—a doll bathing girl dashes up—a great mystery!"

"I once saw something like that where change of temperature outside sent a little thing up and down."

"Is that going to move? Not just this one—I've seen one where a little bottle is brought up by pressure."

"I like these gadgets very much. It reminds me of a picture in a high school physics book of a little devil that bobs up and down."

The investigator's introduction was: "I have here a [32-ounce] bottle, [held by experimenter with left hand], filled with water, in which there is a small glass vial, open at the bottom, and containing a bubble of air. [Cork in bottle had been so adjusted that vial rested on bottom.] If I raise the cork just a little bit, what will happen?"

The first subject to be shown this set-up, at which time the vial was at the top, correctly deduced that the vial would sink. Altogether, 17 subjects correctly foretold that it would go up; however, there were several reservations: four said, "I think"; four added, "a little bit"; one added, "then return to its former position." Oppositely, nine said that vial would not rise; two that it would move from side to side—e.g., "I think there'll be a disturbance [gestures right and left] of the vial." Two said that the vial would turn over and fill with water; nine, "I think it'll stay where it is," or that nothing would happen. Though his prediction was false, one was on a right track, "I think the water in the vial will come up a little." Two others said that some air would come out of the vial. As usual, several persons mixed explanation with their predictions: two said, "the bubble will lift it"; another, "as pressure inside is decreased." One erroneous concept was, "The liquid will expand slightly."

When asked to account for their predictions, a wide variety of explanations was offered by those who said the vial would rise: the most complete, "The air will expand, then its displacement will be greater"; equally cogent, "Specific gravity of tube determines its position." Five made general references to pressure, such as, "Upon release of pressure, air tends to rise in water," and, "Change of pressure on water—pressure per square inch"; another, "You would be decreasing pressure up there? [looks at cork] 'Water seeks its own level,' or something? No, that wouldn't be it. That's just an air bubble in there? [investigator nods] If you release pressure enough, it should go up to top: pressure of air bubble inside equals pressure of water outside vial." Five concluded that air would be entering the bottle, e.g., "Letting air in, of course? ["No."] Seems to me off-hand that you would create a little air chamber on top—that vial is kept at bottom, by what force, I don't know; evidently not enough air in it to raise it—the air above, I should think, would not reach bubble in vial to expand it. It might eventually though, because air does travel through water. How do

you manage to have air bubble in there?" On the contrary, two decided that air would "escape." Each used personification: "The air would want to go in there"; and "Air in vial will attempt to escape." One called in some vague "equilibrium": "You have established equilibrium—I don't know how you did it—air coming in around cork would find its way through water, some way, and the fine equilibrium would be broken." Note that twice the idea of air "travelling" through water is expressed in the foregoing quotations. Four, once more, used "vacuum" or "suction" as their explanation. One, "I can't give an explanation."

Of those who made other predictions, six appealed to "pressure," for instance, "Pressure has something to do with it; if you let air in, it won't disturb the vial"; and "Lifting cork will increase [*sic*] pressure on top of water under it—probably all screwy." One who had predicted that some air would move out of the vial and upward: "If you pull the cork up, you get an expansion—a very feeble explanation; I don't know what exactly would expand—you create a small vacuum and everything would move up to fill it." Those who predicted nothing would happen and the one who recognized it as a Cartesian diver, were not asked for on explanation here.

Actually when the demonstration was given, the cork was loosened only slightly and then the investigator repeatedly squeezed the flat sides of the bottle as he held it in his left hand, so that the vial went back down as he squeezed and rose as pressure was released.

When asked, "What did you see?" twelve subjects nodded, or made no comment, or said, "Goes up and down." One asked, "How do you get it down again?" One, "It rose until it hit the cork; each time it seems to be rising less high—no, that's not true. Would the same thing happen by jiggling the bottle?" Others: "It rose and then found its way to the bottom; but you haven't removed cork completely—that's interesting." "That's right—uh—I didn't know it would go down again. Oh look! it's starting up again—very amusing." "Uh-huh—well, it came up, went down, came up and stayed up. Would you lift the cork completely out? [investigator does so] Would you shake the bottle a little bit? [does so] Uh-huh, it stays up all right! [vial sank again] Nice experiment!" "It goes down again, up again—regular elevator." "Hmm, I certainly saw an almost immediate reaction. It struck the top and was sent to the bottom again; apparently did not have enough air to stay at top in spite of the shock but had too much air to stay there." (This last sounds almost like personification.) Two mentioned change of water level in the vial: "Space in the vial seems to me to be greater"; and "A little water went out of the vial."

Others who asked questions as part of their description said: "Is it going to keep on doing that?" "Can I rock it and see what happens?" (She does so.) "I'm still watching; will it come up again? What if you take your hand off? I saw you exert pressure on the bottle and it went down again—something happened that I didn't expect." "What are you doing now? The heat of your hand doing anything?" "I want to see it again. Did you do anything then?" Expressions of astonishment: "Isn't that wonderful!" "All the way down! My ——! I never expected that!" "Well, it rose more than I expected." "Uh, huh—I was a little surprised it rose the second time." And two alike: "That's what I expected (as it went down)—Magic!" "Magician!" And, "What puzzles me is that there's no evenness to its rise and fall."

When asked for explanation of their observation, four recognized the importance of the compressibility of air; e.g., "Air was compressed; water is harder to com-

press than air; release pressure, it regains buoyancy . . . Pressure bends glass slightly and increased pressure compressed air in bubble; is that it?" Two glimpsed the meaning: "I can't account for it, unless the water level in the vial by moving up and down makes a difference in its weight"; "You increased air space in bottle, which drew water out of vial; so being lighter, it rose to top. It's a coincidence there's a shift in quantity of air and water in vial, not the cause. [Subject squeezes bottle.] I *still can hardly believe* my squeezing makes any change of pressure inside the bottle." Two had exactly the opposite concept: "Vial has more water in it when down; of course air would have to come out for water to come in." Two made physiological comparisons: "Air space in vial increased, same as increasing amount of air in lungs when swimming"; and "I'm trying to compare it to moving the chest—tensing the muscles to expand it when you're under water—but I can't make the connection." Eight here too illustrate Piaget's "simple phenomenalism" or explanation in terms of an accompanying object or event, attributing the result to heat of the hands. Sometimes this is associated with other ideas: "Pressure—you must have a rubber bottle. Is it heat?—it's pressure, isn't it?—it's heat—no, it's pressure; it's a flexible bottle." "It took time to warm up? No, you squeeze. Do it again. [repeated] That means that pressure applied laterally can influence a thing vertically; in any case, the pressure has to be greater than that of the bubble itself." "Well this is too far-fetched, I think: the heat of your hand will expand the air; I suppose it has something to do with the density of water but I don't know what. When you first put cork in did you compress the water? No, it can't—forget that question—I don't know." "I think it was heat of your hand; heat would cause water to expand and make the vacuum disappear." "You must have altered the pressure in the water; what you're doing now is putting heat in from your hand so the water expands; it goes up because there's a vacuum under the cork to which air may go—something about *fluids seeking their level.*" "Heat, pressure—it's rising again. As you warm the—as you press against the glass, from heat the density decreases and it rises; as you relax your grip, it finds its equilibrium at the bottom. [Subject tries it.] That only shows—only experience will show the answer." "The water might push up—no, you'll keep me awake all night trying to figure these things out. Are you sure it's not synthetic gin? I'll believe you if you say it's water. [Investigator repeated his question.] I don't. (Subject touches bottle.) I tell you, you have *magic* in your hands. [Investigator squeezes subject's hand on bottle, vial sinks, subject laughs.] Yes, it's *magic*—would heat have anything to do with it?" Two referring to pressure inferred "currents" as the explanation: "Change in pressure sets up currents which moved the vial." Another, "It still has something to do with pressure; I didn't think the bubble would be *strong enough* to carry the vial up." (This illustrates another of Piaget's interpretations. Piaget considers that this phrase, "strong enough," is an indication of the first stage in pre-causal thinking). Still more vague: "I can't account for it—the only thing is the presence of your hand on the bottle." Other hazy references to pressure include: "You changed pressure so air in bottle is light enough to raise vial; seems almost *miraculous* that such slight pressure will change it." "No more air got in? ["No."] Raising cork exerted an upward pressure throughout the bottle and in some way *activated* the air inside." "Has pressure of your hand anything to do with it? [hand removed] It would seem pressure is released so it's gone to top. A current pressed on top of vial. Can I rock it and see what happens? [does

so] Won't go down again. [subject shakes head] You've got me on that one completely." "It must be the pressure of the outside air; there must be a certain amount of air released into the big bottle. When pressure in lower bottle is same as in top of big bottle, it'll rise. I don't know—this is too much, much too much for me. How little people, supposedly of the literary fold, know about other things!" "How it works is by pressure [subject tries it] but why it works I don't know."

Five concluded that air was admitted around the cork: "More air got into vial, which I confess I don't understand; there wasn't any increase of air, but an expulsion of water which made vial lighter." "I don't know what happened at all—I didn't think about its coming down but I did think about its rising. You let in some air and its pressure forced it up; as it rose the pressure under vial is greater than pressure over it. ["Why did it go back to the bottom?"] Some *principle of equalization;* did your taking hold of it have anything to do with it? [nod] Pressure over vial pushes it down." "The air you let in must have gotten into the vial or it wouldn't have come up and then, as a crude guess, I would say that it went to the bottom again because there's more water than air in the vial." The above "principle of equalization" resembles another reply: "The *air went through the water* and increased the air in the vial. These are very interesting. *Nature* works much more rapidly than I gave *her* credit for—that's the trouble with my answers." And personification again: "It's *trying* to find its level with readjusted weights some way, but I don't understand how—I don't know the explanation." Expressions of complete bewilderment: "Well, naturally air is lighter than water. You got me—I don't understand that at all. There must be some forces—in other words, the force of gravity—no, I can't figure that out. I'd be very glad to know why it does that." "I don't think I can account for its going down, unless there isn't enough air to keep it up." "I don't know at all."

Of the 35 subjects, four tried the experiment for themselves; five others were told to do so. The italicized words in the above quotations are worthy of note.

Demonstration no. 7. Ring finger

This problem was used by Keen [9] and its anatomical basis is shown in *Applied Anatomy and Kinesiology.** The investigator introduced it to each subject by saying, "For this experiment, you are the apparatus. Hold your hands so that tips of fingers are together [investigator does so]; now fold middle (third) fingers down toward palms till second joints (knuckles) are together; now move thumbs apart, without moving other fingers, and together again. From here on do not move any part of your hands as I ask you the next two questions: Can you move each of the fingers apart, as you have done the thumbs, without moving the others? [Subject makes prediction, usually accompanied by close scrutiny and tensing of muscles.] How do you account for it?"

When prediction was called for ["Can you move each finger separately?"], the correct one—the second and third but not the fourth—was made by 26 of the 34 who participated. One of them said, "I can tell from tension in ring finger that I won't be able to do it." Another predicted that the index finger would be the only one." One, "No, not any." Others were uncertain: three said, "I think so"; one, "I don't know, I think I can, but since you asked me, probably I can't"; another, "You can if you're clever." One asked, "It's a question of my nerve reactions, isn't it? ["Not exactly."] Is it a physical question? ["Yes."] I'd say I can."

When asked, "How do you account for what will happen?" eleven gave specific

* Bowen, W. P. and McKenzie, R. Tait. *Applied Anatomy and Kinesiology,* p. 142. Lea & Febiger, 1923.

anatomical explanations, of whom two correctly referred to the arrangement of tendons, seven to the muscles, and one each to bones and " pads " on the fingers. Another said, " I don't know why, unless there's some anatomical or physiological reason." Of the more general replies, seven included the opinion that it is somehow the result of the arrangement of the fingers: " It may be because middle and ring fingers are in center of the four fingers." " Ring fingers are dependent on the fifth or third." " Middle finger folded takes up all the strength." " Strain on fingers, due to one folded in." " It couldn't be because it's closer to central pressure. I don't know, I'm afraid. It must have something to do with the length—the arch. The pressure of the ring finger is much greater than of other two." " The two fingers are locked and one is tied up so I can't move the other one." " I've tied up a muscle somewhere; index finger is sort of on its own." "Apparently the connection of muscles here—I'm not certain. With middle fingers in this position, I have no control of muscles of ring finger." " Because they—you can move little fingers because you don't have that line to upset—I don't know how to express it. You can move the muscles more easily, same as index fingers." " Well, maybe 'cause others are so short; that's like a keystone arch there in the center."

Nine interpret the situation in terms of exercise or practice: " Of all my fingers, they are weakest and muscular control is less. I know that from typing, even ' pinkie ' is stronger." " Ring finger most difficult to use independently when playing piano and same in children's games." " I haven't practiced it." "Atrophied muscles; I'd say I'm sure with practice I could." " I haven't motor control; if I were a violinist, I certainly could." " Either the muscles of ring finger are not developed or middle fingers have not the ease of movement that the other two have." " Because it isn't flexible enough." " I don't really know. There seems to be more pressure there. They're rigid—others seem to be flexible." And three used even vaguer terms: " It seems to have no leverage." (See "keystone arch," quoted above.) " I don't know really—maybe not enough coordination, power, or whatever it is." And one said merely, " I don't know."

Those who predicted they could move all fingers: " You can if you're clever, but ring finger is kind of weak." " I think I have independent control of each finger in spite of middle finger being folded." " If you ask me ' why? ' I'd say ' Why not? ' " And two gave no explanation.

Subjects were then told to move each finger separately. All who made correct prediction nodded or said, "As I expected," " Can't do it," " Fourth can't budge," etc.

In answer to the investigator's question, " How do you account for what you saw? " seven mentioned tendons (or sinews or ligaments); four referred to bones, eleven to muscles, and two to nerves. Included is one person who referred to three of these: " The way the hand is built, I've no way of knowing whether one bone, one muscle, one ligament prevents its working." Another, " It may be—I don't know—that the same nerve is tied up with a sinew there; it must be tied to a tendon so it cannot move independently." The most accurate were: " Because muscles and tendons are crossed over metocarpals." " Common tendon." " Much less span than middle finger; they must be on the same tendon or something of that sort." Here, four again refer to arrangement or position of fingers: " Same as before, apparently the connection of the muscles here—I'm not certain—but when middle finger in this position, I have no control of muscles of ring finger." " It's a bridge—holds the weight, unless I move all apart—that's stupid; that's no explanation at all." "As I said [looks at each

side], it may be because the middle and ring finger are in center of the four fingers." "Well, it's in between—it's locking someway; others are free." And fourteen make quite general explanations: "They're tired; they're not free agents. When the third fingers are folded, the fourth are already extended and can't bend back—the strain to keep the middle folded makes it impossible. Wouldn't the ability vary with different people? ["I think so, yes."] "Partly anatomical at least." "I must admit that I am at a loss as to just why those ring fingers are together so you can't pull them apart unless some anatomical structure prevents—that's hardly true, there must be something in Physics that explains the reason for it." "I just think of it as being something physical, some mechanism in those two fingers that in this position one can't pull them apart." "I still stick to the other explanation that the little finger mechanism is not affected by ring finger mechanism so much. Let's see, there must be a physical law there. Well, little finger can, 'cause it's at end and there's nothing to hold it in; in other words, it's more independent than ring finger is." "Some connection between third and fourth fingers." "Some muscular or nervous tie-up between them and middle fingers." "Something to do with bone structure, something more than motor control." "Contact between knuckles is so close that they both work together." "Is ring finger longest? [looking intently] I don't know except that maybe ordinarily you can't do as much anyway. Let me take a guess—there's a closer articulation between ring finger and middle finger; and since this is bent, it keeps it down." "Ring finger is longer than index or fifth and on longest falls the greater amount of pressure and on it would rest the weight of the whole structure; also not as great flexibility in ring finger as in others—I'd say *retractility.*" "I feel impulse for ring finger in third; I can't apply force to finger tip, it *gets diverted* into knuckle." "Bones are set so as not to give proper leverage." "Folded middle finger deprives ring finger of necessary support." "A pressure—middle fingers shortened so the whole balance falls on them." "They're wedged in and there's a lack of balance or something." "I don't know; there just simply must be a hook-up." One merely, "I don't know." Personification is marked in this statement: "I don't know, maybe something to do with the way muscles are arranged; the muscles don't seem to understand what's wanted to be done. There's some explanation, but I've forgotten." Also in quotation above: "They're tired; they're not free agents."

Discussion and Comments

The comment of a stenographer who typed these materials was, "It's most interesting. It had me dropping pieces of paper all over the place. Their answers are so typical of teachers: it wasn't the experiment, but, 'I was right' or 'I was wrong.' It should be called a study of the psychology of teachers."

Several other investigators have compared children and adults, including Abel [1], Deutsche [3], Harter [4], Hazlitt [5], Heidbreder [6], Huang [7], Jersild [8], and Keen [9], as well as Piaget [12]. Abel, Huang, and Keen had as their adult subjects college students, chiefly undergraduates; the subjects of this study had considerably more academic training and considerable teaching experience in non-science fields. Whereas Piaget makes a clear-cut distinction between the thinking of children and adults, Abel concludes that the type of thinking is dependent more on the type of individual (child or adult), the extent of development of his psychological functions (including intelligence), his past experiences, his organic set-up at the time of being observed, and his cultural heritage. Harter, using non-

verbal tests, reports performance by adults similar to that of children who succeeded on the tests. Hazlitt, testing children and adults on the ability to make exceptions, found no real differences between the thought processes of children and non-scientific adults. Jersild, discussing this problem, states, "There is no essential difference between the reasoning of children and the reasoning of adults. The reasoning of both really involves the same processes. That the child's conclusions are sometimes bizarre and absurd, that he seems irrational and unable to make correct inference at times, doesn't mean that the adult is a rational animal while the child is not." The others mentioned above agree with such conclusions rather than with those of Piaget. The findings of the present study add further evidence which seems to be contrary to Piaget's views.

Relying on authority; having the attitude that anything can happen, implicit in the familiar expression, "that beats all"; neglecting to demand evidence upon which reliable conclusions may be based, and not knowing how to recognize or interpret such evidence—these do seem to be habits that are widespread. In general the adult has a more fully developed system of knowledge but where a correct concept is lacking, the adult explains the event naively, just as does the child. The children studied by the present author [11], gave responses which, although a few are enigmatic, are mostly matter-of-fact or naturalistic, rather than animistic or magical.

Adults of the present study more often made comments of personal opinions and feelings than did the children of the study mentioned in the preceding paragraph. In it, only a few children in each grade-group made such remarks. For example, after a demonstration relating to the problem, Why do ice cubes stick together? a kindergarten child said, "This is a game, isn't it?" A sixth grader inquired, "What do you do with all these?" She was told they were to be used in planning what science to teach in the grades.

Various remarks and asides of the adults who cooperated as subjects in this study seem so characteristic as to be worth mention. Very few of these expressions are matched in the protocols of the children [11].

Apologetic Remarks

Of the 35 subjects, 18 (51.4 per cent) made a total of 30 comments which are apologetic or self-deprecatory. One stated, "I'm not very bright at this." Seven referred to themselves as "stupid," "dumb," "foolish." Another, "You see what a vacillating creature I am—I never passed a science course in my life," and also, "I'm being brilliant so far" (of course, ironically). A third example, "A little distressing how little one knows." Others referred to their explanations as "feeble," "phoney," "screwy," "crude guess." And, "How little people, supposedly of the literary fold, know about other things!"

Personal Reactions

Twenty-two subjects (62.9 per cent) made 46 statements of their impressions, feelings, and suggestions regarding the investigation. Nine, on various parts, remarked, "interesting," and one called the Cartesian Diver "very amusing"; another called it "wonderful" and also said of the Paper on Boxes, "Oh, that's wonderful! Will you do it again?" Four said they had "fun"; one said it was "painless"; two expressed disappointment that there weren't more than seven experiments. To quote a few others:

"I like these gadgets very much."
"You're giving me tricks to try on my friends."
"I wish I had your apparatus—I'd like to go around fooling them, too."
"That's an interesting idea for birthday cakes, too."
"Boy, am I gonna have fun!"
"Biology was not considered nice where I went to school."
"I don't think in the convent they would let me play around with things like that."

Certain comments had to do with the nature of the questions and inquiries as to the purpose of the investigation. One, "These are subjective questions," and on another experiment, "Gimme some hard questions." Another, "They get better as they go along, don't they?" and one, "These are getting tougher and tougher." One suggested the use of a dictagraph.

Eighteen subjects used altogether 21 *expressions of surprise* or otherwise indicated that what they saw was not what they had expected. In the Candle and Jar experiment, two stated that they had thought the candle was to be put in the jar. Two others used the words, "That's funny."

References to Memory

A total of 18 comments were made by 13 subjects (37.2 per cent) referring to recollections, memorizing laws, and the like. Four were expressions, "faintly" or "vague memory." One, "I did know at one time but not now: it's worse than being unfamiliar with it, because I'm more confused than ever." Another, "My memory makes me think that . . . ." Three mentioned scientific "law," including, "I memorized the law once, but I don't remember." Also, "That has revived memories, but I'll probably soon forget again."

Another characteristic related to memoriter learning is the tendency to use certain catch words as explanations for a number of phenomena superficially similar. The outstanding illustration of this sort is the use of the idea "suction" (or "vacuum") to account for the effects of any change of air pressure as well as for those of currents in fluids. Another example is the expression "upset equilibrium" used in several situations. One subject used, "fluids seeking their level" to explain the Cartesian Diver, and also spoke of a "threatened vacuum" between the jar and the candle, based apparently on the adage, "Nature abhors a vacuum."

Tendency to Mysticism

Several statements (23 comments by 18 subjects) contain more than a hint of the extra-physical. To be sure no one can be an authority in all fields of human knowledge; it is also true that achievement of eminence in one specialization frequently leads one to make pronouncements in other matters, as when a famous aviator writes magazine articles based on a supersition in anthropology and when an eminent physicist states his opinions on education. However, the comments of these subjects seem to illustrate that the fundamental basis of science is not yet universally recognized and accepted. The concept that natural phenomena have natural causes, confidence in the methods of careful observation and experiment, willingness to revise opinions on the basis of new discoveries—these are not ingrained as parts of our folkways. Remarks of the sort considered here were not made on the experiment with the Ring Finger. One subject at the beginning of the series (Two Sheets of Paper) remarked, "It's a long time since I studied any science, maybe Nature has changed a little." Another on the second (Paper on Boxes) stated in the prediction, "I'd say it's unpredictable . . . anything won't surprise me." On No. 3 (Card and Spool) one said, "I'm prepared to believe it will stay," after predicting card would fall; another, "There's something mystical about these things—the obvious thing isn't true;" a third subject, "That means the air is misbehaving;" on No. 4 (Jar and Candle), "Since air is misbehaving, I don't know what to expect," on No. 5 (Falling Bodies), "It seems a bit unfair that the iron one doesn't get there first," and on No. 6 (Cartesian Diver), "These things are passing strange—more things than are dreamt of in your philosophy." Several comments indicate reluctance to believe one's own eyes: "I still believe the heavier one fell first—but it's very close"; another, "I still can hardly believe that

my squeezing makes any change of pressure inside the bottle"; and another, "Seems almost miraculous that such slight pressure will change it." This reluctance to trust observation is implied in statements indicating reliance on "common-sense," "instinct," or "logic." In other words, a change in belief would not be "reasonable," according to the following statements:

"My common-sense tells me that they won't—but with air resistance the same, they ought to hit at the same time."

"It would appear unlikely, but I seem to remember that the pull of gravity would be the same. There's where education comes in—a case of knowledge versus common sense."

"Maybe my eyes aren't good; yet from practical experience, we know a light object will not fall so fast."

"I think in my common everyday experience, heavier articles seem to fall faster than light ones."

"In Physics they fall together, which actually they do not."

"It just seems sensible to me [that heavy one falls faster]. I don't remember the laws."

"If I had never learned about such things, my instinct would be to say the heavier would get there first."

"My suspicion is that what one first thinks is wrong."

"Just a matter of logic [heavy one first]—I don't know whether logic is useful in Physics."

"Magician! It doesn't seem possible, but it must have been that." [Pressure on bottle, Cartesian Diver.]

"I tell you, you have magic in your hands."

"Nature works much more rapidly than I gave her credit for."

Two subjects gave statements of scientific attitudes which were not borne out in their own explanations: "Being a scientist, I'll have to revise my theories." "That only shows—only experience will show the answer."

Several frankly admitted that their explanations were guesses. It is of interest to note that 21 (60.0 per cent) asked for the correct explanations of the phenomena. Of these, five inquired about the Cartesian Diver only. Whether the others hesitated to inquire because they were too modest, felt that they hadn't the time to spare, or simply because they lacked curiosity, is, of course, not known. It is also true that one or two understood most of them already.

Finally, it should be pointed out that a number of the responses classified as Physical types of explanations indicate that the subject has no clear understanding of the true causal factors involved. Such responses are classified by Black [2], Huang [7], and others as naive, vague, irrelevant, and the like. Black quotes Ernst Mach as calling such concepts "instinctive" and defines them as "notions that were built up unreflectively without any consciously directed thinking . . . the vague or naive notions which the study of science is supposed to develop into logical or scientific concepts."

These adults exhibit very little in the way of a consciously reflective or logical procedure in attacking problems with which they are unfamiliar.

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AIRSHIPS, LEVIATHANS OF THE SKIES

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THE application of U. N. Airships, Inc. to the Civil Aeronautics Board for Certificates of Necessity and Public Convenience for airship routes covering some 42,000 miles of transoceanic routes between important world terminals in the four quarters of the globe, has resulted in a nation-wide interest in airship transportation which has lain dormant since the failure of the German Zeppelin Company to get a supply of helium gas from the United States in 1937.

For eight years the German company had operated large dirigible rigid airships regularly between Europe and the United States via South America, without a scheduled flight being deferred or canceled. In eight years operation under all sorts of conditions, not a single passenger had been even slightly injured. The only accident occurred after a flight from Frankfurt, Germany had been completed and the *Hindenburg* was cruising around at Lakehurst, New Jersey, for publicity purposes. Possibly as a result of a back-fire of one of the engines, the highly inflammable gas with which the ship was inflated was ignited, and before the ship could be landed and the passengers debarked, 13 passengers and 23 of the crew, out of a total of 97 on board, had lost their lives. Had the ship been inflated with helium gas which is non-explosive and non-inflammable, no accident could have occurred.

At that time and at the present time, the United States is the only country possessing a supply of helium gas, hence this country is the only one which is in position to operate airships with absolute safety. After the accident to the *Hindenburg,* the German Zeppelin Company laid up the *Graf Zeppelin,* which had been in continual operation for eight years, and did not put into commission two other ships even larger than the *Hindenburg.*

The Zeppelin Company hoped to get helium from the United States to inflate and put all three of these ships into operation, but in 1937 Congress passed an act forbidding the export of helium gas for airship inflation. While the United States and other countries had experimented with dirigible airships for military and naval purposes, only Germany had operated commercial airships, and the present applications pending before the Civil Aeronautics

Board are taking up where the Germans left off nine years ago.

During these nine years, great improvements have been made in aluminum alloys, engines, and fuels, so that while the general principles are little changed, the airships which will be operated under the pending applications are far superior to the airships of nine years ago. Owing to the improvements in alloys, the weight of the ships will be greatly reduced and at the same time the structure will be measurably stronger. Engines will weigh approximately one-fourth as much as the engines of nine years ago, and this reduction in weight will add approximately eight tons pay-load capacity. Improved control systems will make operational accidents, such as those which wrecked the Navy dirigibles *Akron* and *Macon,* an absolute impossibility. The conventional features to be embodied in the new ships represent the evolution in design and construction of more than 130 large rigid dirigible airships.

All post-war airplane plans are based on large planes with a cruising speed of 240-350 miles per hour, and to acquire such speed means an exceedingly high operating cost. For this reason the pay loads of these high speed planes are limited to those producing the highest revenue. These are passengers and special air mail. Except for an insignificant amount of high-revenue express, every other class of commodity is barred by inability to stand the necessary charges. The average airplane pay load is made up of 75 per cent passenger traffic, 20 per cent special air mail, and 5 per cent high-revenue express.

The airship, on the other hand, has no such limitations and can carry profitably any class or kind of cargo up to the full extent of its carrying capacity. The largest airplane now developed for post-war service has a maximum pay-load capacity of 28,000 pounds for a 3,000 mile non-stop flight. The airship over this same non-stop flight would carry a pay load of 160,000 pounds, and in fact can carry such a pay load on non-stop flights of 6,000 to 8,000 miles. No airplanes have been designed and built as yet which can operate on non-stop flights in excess of 3,000 miles with a pay load of sufficient size to make the operation profitable. Airplanes used for military and naval purposes have operated longer distances but with very light pay loads and at costs which are prohibitive for commercial operations.

Perhaps the most difficult thing for the layman to understand in regard to airships is that the cost of carrying a maximum pay load of 160,000 pounds (for a 10,000,000-cubic-foot ship) is no greater than the cost of carrying a single pound. In air transportation, two natural laws have to be overcome, those of gravity and inertia. In the case of the airplane, large expenditures of mechanical energy are required to lift the load in the air and to transport it through the air. In addition, certain speeds must be maintained at all times to keep the plane airborne, and any reduction below these minimum speeds results in a crash. In a flight, if the engines fail, or fuel is used up, the plane must land whether it is over an airport, over a mountain, or over the ocean. In the airship, the force of gravity is overcome by employing another law of nature—that of the diffusion of gases. The ship and its maximum load are lifted and become airborne without the expenditure of any mechanical energy. To transport the ship and its full pay load, mechanical energy is expended only to overcome the pressures developed by speed through the air and the skin friction. That is why the size of the pay load makes no difference in the operation of the airship. If the engines of the airship should fail or fuel run short, no forced landing would be necessary. The airship could remain airborne for days if necessary without any expenditure of mechanical energy. For example, on a trip to the United States via Brazil, the *Graf Zeppelin* was warned by radio from

its home base that a revolution was in progress in the province in which the Brazil base was located, and that it was not advisable to land until the situation cleared. The *Graf Zeppelin* merely cruised around for three days waiting for the situation to clear, and then proceeded to land.

Many persons have the idea that there is a conflict between the airplane and the airship—an entirely erroneous conception. High speed is the dominating factor in the airplane, and the airship does not enter into that high speed competition; neither does it penetrate the particular pay-load field peculiar to the airplane and its limitations. In the matter of pay-load classes, the airship takes up where the airplane leaves off. Only 10 per cent of the airship pay load is represented by passenger traffic, and facilities are provided for a limited number of "de luxe" passengers who desire to travel in luxury and comfort not obtainable in the airplane, and at speeds four to five times faster than the ocean steamer. The other 90 per cent of the pay load of the airship is composed of ordinary mail (which cannot be carried by the airplane without heavy loss), including the low classes of parcel post, express, and whatever commodities are available to make a full pay load at all times. Naturally, the pay load will be made up of as high a class of commodities as are available, but in event of not having higher classes of commodities for make up a full pay load, the full load will be completed with any class of commodity offered so long as it produces any kind of revenue. As it does not cost any more to operate a fully loaded airship than one partly loaded or empty, a full load will be transported at all times.

The plans for airship operations under the pending applications do not provide for any domestic operations, the operations being limited to long over-ocean "hops" between important world terminals. The longest non-stop flight on the present routes is approximately 5,000 miles, which will be negotiated with the maximum pay loads. In accordance with the policy of limiting the seasonable passenger pay load to 10 per cent of the total, the 10,000,000-cubic-foot capacity ship will provide cabin facilities, baths, cafeteria service, and other conveniences for a maximum of 100 passengers who desire to travel in luxury, comfort, and ease. The 6,500,000-cubic-foot ship, which will be operated on certain lines, will carry 60 tons pay load on 6,000-8,000 mile non-stop flights, with provisions for 60 "de luxe" passengers.

While the airship fills a part of the ever-widening gap between the ocean steamship and the high speed airplane, it does not fill the entire gap by any means. The average steamer speed (excluding the few luxury liners such as the *Queen Mary* and the *Queen Elizabeth*) is around 20 miles per hour, with the high speed airplane ranging up to 350 miles per hour. While it is quite possible to build and operate airships at speeds up to 150 miles per hour, such operation would not be either profitably or economically sound. The ship structure would have to be made very heavy, and the engine and fuel requirements would be very heavy. Careful study of operating economics has determined that the optimum speed for operation of the 6,500,000- and 10,000,000-cubic-foot airships is 85 miles per hour, or more than four times the speed of the average ocean steamships. Careful and detailed studies have been made of the traffic generating potentialities in different countries and parts of the world, and the terminals for the routes have been selected from the studies made. As the principal objective is the transportation of commodities between various world terminals, it is pertinent to note that more than four hundred classes of commodities have been catalogued and listed, of a class which will stand airship transportation and which move regularly the year round between the selected

terminals. Of the available commodities which will stand the charges necessary for economical airship transportation only 5 per cent is required to provide full pay loads for initial phases of the proposed operations.

The optimum airship speed of 85 miles per hour is the speed that will be maintained throughout the trip. The ships carry reserve engine power which will be used only when necessary to maintain the optimum speed against head winds or other conditions. In maintaining schedules and speed, it is to be noted that the airship has few limitations by reason of weather conditions. The airship can take off in weather which grounds all airplanes, and "dock" under fog or other conditions where it would be fatal to attempt to land a high speed plane.

Of the three routes to various world terminals for which operations have been fully planned, two have been presented to the Civil Aeronautics Board, which has held hearings, and on which administrative action is now pending. Of these two routes, one starts from the main base at Washington, D. C., and goes to Bombay, India, with intermediate stops at Recife and Rio de Janeiro, Brazil; Buenos Aires, Argentine; Cape Town, South Africa; Mombasa, Kenya; and thence to Bombay. The return is made by the same route. The second route is from Washington, D. C., to Canton, China (which includes the Hong Kong area), with intermediate stops at Los Angeles, Honolulu, Manila, and Singapore. The return from Canton is direct to Manila; the remainder of the return trip retraces the out-going route.

Many items of equipment will be found in the new ships which were unknown in the airships of nine years ago. Two 100-horsepower Diesel-driven electric generators will furnish current for lights, electric ranges, heating (when heat is necessary), electric refrigerators, and radio stations with 5,000 mile range, as well as for operating winches and hoists for loading and undlooding cargo, controls, and so forth.

The rigid airship by virtue of provisions for "de luxe" passenger travel, with the maximum of safety, ease, and comfort, is at once the "Queen of the Skies," and the "work horse" of cargo transportation and the term "cargo" includes all classes of mail other than special air mail, a wide range of commodities, and express. The airship pay loads will not penetrate the high speed airplane field. It is estimated that only one-third will penetrate the steamship field, for it is believed that the advent of airship transportation will develop a new line of business in the transport field.

The widespread interest which has been aroused by the revival of airship transportation indicates that the public is ready and waiting for this safe, economical, and relatively fast commodity service.

TEACHING REPORTS

The editor of this department reminds the reader of the general plans for a department of teaching reports and suggestions, as set forth in the issue of April, 1944 on page 175:

"This department would include reports of teaching in science classes at various levels—articles which make readers feel that they have visited the authors' classrooms; suggestions for field trips, including specific plans for trips to study such subjects as housing, plant succession, and agricultural products; evaluation materials which could be reproduced for use in classes, especially instruments designed to test reasoning, critical thinking, and attitudes; directions for unusual experiments and for making handy gadgets; and suggestions for the use of visual and auditory aids."

To such ends as these this department is dedicated. It will prosper only as it becomes a cooperative activity. Doubtless each reader can make a contribution to this department either from his own experience or through another person whose work deserves recognition. Will you make your own contribution or call the attention of the editor to others who may be asked to contribute? Your assistance will be greatly appreciated.

—J. S. R.

ACTIVITIES IN A HIGH SCHOOL GREENHOUSE

Included in the Cuyahoga Heights, Ohio, School District is a vegetable producing area with approximately thirty-nine acres under glass. The products are chiefly greenhouse tomatoes, lettuce, and radishes. Because of this, a greenhouse was included in the building program of the school that serves this community.

The school greenhouse is 44′ by 76′ and is divided into five rooms. It is composed of two even-span houses, each 22′ by 76′, with a glass partition between the two houses. The five rooms are heated and ventilated independently. This makes possible the growth of a wide variety of plants. The so-called "warm room" usually has a night temperature of 60° Fahrenheit; it is used principally for roses, gardenias and any other plants that require warm temperatures. Such plants as chrysanthemums, carnations and stock are grown in the cold room, which has a night temperature of 50° Fahrenheit. Most soil mixing, potting, and similar work is done in the work-room; such potted plants as geraniums and cineraria are grown in this room. The hydroponics room is equipped for gravel culture. Some chrysanthemums are usually grown in the summer and fall, and some tomatoes are produced in the winter and spring by this method. Chrysanthemums produced in gravel culture have been superior to those grown in benches. The largest room is the vegetable room. It is devoted chiefly to tomato production. Crops of lettuce and radishes are occasionally produced when no tomatoes are being grown.

The greenhouse class is conducted almost entirely on a pupil activity basis. All the work is done by the pupils except the necessary care over week-ends and during vacations. For example, a plot of ground for tomatoes is assigned to a boy. He cares for the crop from seed planting until the vines are pulled. He keeps a complete record of his crop. A section of a bench may be assigned to a girl for snapdragons. She does the work in connection with this crop from seed planting until the flowers are cut. After the crop is completed the pupil writes a condensed report which is filed under the heading for this particular crop. This report is known as the Grower's Record.

Many problems arise from such an assignment. Such problems include the method of planting the seed, how to stop "damping off," how far apart to bench the plants, the quantity of fertilizer, and the control of certain insects. The learning comes chiefly through attempting to discover answers to such problems. The pupils have various sources of basic and supplementary information. The first of these is the instructor. He works with the pupils, makes individual and group demonstrations, offers corrections and suggestions. Many questions are answered by the instructor; others are referred to other sources. There is considerable informal individual questioning while pupils are at work. This serves as a review and stimulates further reference work. A second source of information is reference books, pamphlets, and catalogs pertaining to the growing of plants and related problems. A third source is the "Grower's Records" that have been filed.

All pupils should have a certain amount of basic knowledge. In addition to the discussion and reference work on specific problems all pupils write out the answers to a series of basic questions regarding plant problems, fertilizers, soil conditions and insect control. Pupils may use references and discussion among themselves and with the instructor while answering these questions. These lists of questions are usually posted on the bulletin board; after a period of time new lists are posted.

There are numerous related activities carried on in the greenhouse. One of these is soil testing. Boys learn to make rather complete soil analyses for available minerals and *pH*, and make recommendations based on the results. Soil samples for analysis are received from gardeners and others. Fertilizer deficiency studies are carried on with tomatoes, using wooden boxes for gravel culture. The solution is supplied from an elevated pail which is connected to each box with a piece of rubber tubing. The tomato plants grown in these boxes are fed different solutions. One group of plants may receive no nitrogen, another no potash, etc. In this way the symptoms of specific fertilizer deficiency can be observed from the beginning to the advanced stages. Another type of experimental work is the use of growth stimulating hormones. When applied to the flower of the tomato plant these hormones stimulate the development of the fruit.

The plants for the school gardens are grown by the greenhouse class. Many plants are started in the spring for the pupils to take home for their floral and vegetable gardens. Most of the flowers grown in the greenhouse are used in small floral arrangements. The pupils are taught to make corsages from such flowers as carnations, gardenias, and roses. Stock, snapdragons, and other cut flowers are used to make floral pieces used at many school functions of social nature.

It is not often that a high school has a greenhouse. In many communities a wide range of greenhouse activity would not be practical. However, in many schools a small greenhouse would be a useful addition to the biology or agriculture department.

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Cuyahoga Heights, Ohio

KEEPING UP WITH SCIENCE

A conscious effort was made toward a fuller realization of an objective of science teaching in the writer's class in ninth grade general science. The objective aimed at a greater understanding on the part of the pupil for current happenings in scientific research and discovery. The usual method of class perusal of newspapers, magazines, and other sources, with the ensuing reports, sometimes proves stilted and formal; a more flexible, socialized method in which the full imagination and resources

of the student were permitted proved to be highly satisfactory.

Committees of three students were appointed each week. The responsibility of these students was to present, using methods of their own choice, pertinent problems in science. Science Newsletter, The Scientific American, and other current periodicals were common sources of information. Great originality was forthcoming in the methods used in presenting this material to the class group. Presentations ranged from the highly socialized "quiz program" to the more formal class report. Round-table discussions, debate and group discussions were often used. Visual presentation with motion pictures, charts, and lantern slides (both homemade and commercially prepared), and the use of mimeographed materials are examples of methods used for presenting these materials. One class period in five was not considered by the group to be too frequent and interest ran high throughout the entire series of programs.

ARTHUR L. ASSUM
University of Chicago

AN IMPROVISED ROTATOR

The adaptation of pieces of equipment to uses other than their original often provides the science teacher with valuable demonstration or laboratory equipment at little or no cost. In some cases the adjustments necessary are in themselves learning activities. Such a piece of equipment is the spring motor and turntable from an early phonograph. Such instruments are generally obtainable at low cost.

The mechanism is removed from the cabinet for ease of use and economy of storage space. It is mounted on two wooden pieces (*A* and *B* in Fig. 1) of such width that the spring motor is held above the table top. The turntable has a variable speed control; this gives the rotator, as it has now become, additional value. Some uses for the device are described here.

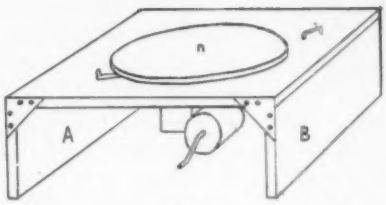

FIG. 1

Electrical Generator—A horseshoe magnet is mounted between two wooden pieces which serve as its support. These pieces are about 6" long and are held together with a stove bolt (Fig. 2). A coil consisting of 75–100 turns of #30 insulated copper wire is made of dimensions such that it may be turned easily between the two ends of the magnet. The magnet is centered on the rotator and the coil is suspended directly over the center of rotation. The ends of the wire from the coil are attached to a galvanometer. As the rotator turns, the deflections of the galvanometer needle indicate the generative action of the device. By varying the speed of the rotator an approach to the idea of a 60-cycle generator is provided. Variations

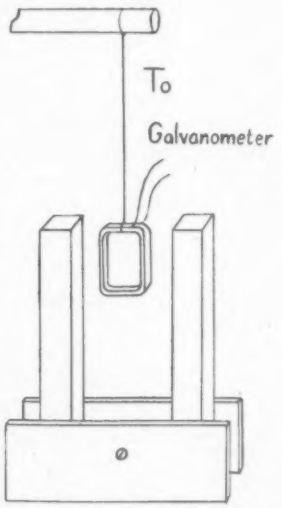

FIG. 2

such as a rotating coil and an electromagnetic field suggest themselves.

Centrifugal Force Demonstrator—A wooden block measuring 4″ x 4″ x 1″ is made. A hole is drilled at its center to accommodate the pin at the center of the rotator. The block is placed on the rotator (over the pin), and upon it is placed a beaker which is about one-fourth filled with water. The beaker is centered on the axis of rotation. As the rotator turns, the action of the water shows the centrifugal force developed.

The centrifugal force may be demonstrated and studied also by the use of a dowel pin of about 6″ length. The pin is fastened securely in the hole of a block such as that described above. Care should be used that the pin is vertical. A thin saw blade or knife is used to make a small slit in the pin across its top (in the position of its diameter). A string of about 10″ long is attached at either end to equal weights. These weights may be approximately 10 grams each. The string is placed in the slot at its midpoint, the weights hanging at the side of the pin. As the rotator turns, the displacement of the weights indicates the centrifugal force developed. The application of this principle in the governor may be studied in the speed control mechanism on the under side of the rotator.

Simple Harmonic Motion Demonstrator—A small board or piece of lath of about 6″ length has a hole drilled near one end to fit the pin at the center of the rotator. At the other end a dowel pin of 3″ length is attached to the lath with a brad, so that the pin is in a vertical position. At a distance of 20′ or more a lantern-slide projection lantern is placed so that the apparatus is illuminated. The shadow of the rotating pin is thrown on a screen which is placed about 2′ from the rotator. The motion of this shadow is approximately simple harmonic. Other uses will suggest themselves such as comparison with a pendulum.

Other Uses—The rotator will carry stroboscopic and color discs. These are placed in the position in which phonograph records are ordinarily carried. A siren disc may also be used on the rotator by placing it slightly above the plate. This is accomplished as shown in Fig. 3. A

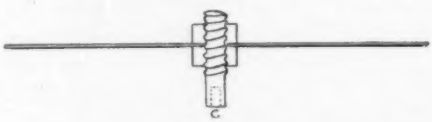

FIG. 3

short length of bolt which fits the hole at the center of the siren disc is mounted with a nut on either side of the disc. A hole of such diameter that it fits snugly over the pin on the rotator is drilled at *C* along the axis of the bolt. Its depth is such that the pin will slip its entire length into the stud thus produced. The siren disc may then be used in the customary way.

J. S. R.

EDUCATIONAL TRENDS

SOME PERTINENT FACTS ON THE RELATION BETWEEN HIGH SCHOOL AND COLLEGE EDUCATION

IN the March issue of SCIENCE EDUCATION the viewpoints of two eminent scientists were presented regarding the document of the Educational Policies Commission entitled *Education for All American Youth.* [1] These viewpoints included serious questions concerning the probability that secondary schools would satisfactorily discharge their college-preparatory functions if they modified their curricula in the direction proposed by the document.

It is appropriate and timely that these questions be raised. Science educators cannot afford to allow curriculum modifications that will affect adversely the preparation of adequately trained technicians and scientists for leadership in this age of technology and science.

But the proper function of the secondary school and its best articulation with the college are far from clear. Statements of policy on the problem have been made by various educational organizations during the past decade. More important, a fair amount of data has been developed that are basic to any sound position regarding the secondary school's college-preparatory function. Some of these data have recently been brought together by J. Paul Leonard, and will soon appear in a leading educational journal. To assist the science educator in forming a tenable position on the problem, these data are here summarized together with other data of particular interest to those in the field of science education.

HIGH SCHOOL AND COLLEGE POPULATIONS

The growth of the high school population in this country since the turn of the century and the present constituency of our schools are basic data of prime importance. According to the Biennial Survey of Education, 1934–36, about 70 per cent of the youth of high school age—6,886,553 individuals—were in attendance in the high schools of the nation. Of these, approximately 65 per cent fail to graduate, and about 20 per cent go on to college. Of those who begin college about 95 per cent do not graduate.

Clearly, the college-preparatory function of the high school is directed to not more than 20 per cent of high school youth at the maximum. Yet, to the extent that college entrance requirements and pressures from the colleges influence the high school curriculum, the work of far more than this 20 per cent is effectively determined by the presumed college-preparatory function of the secondary school. According to the national survey of secondary education in 1932, 65 per cent of the time of youth in high school was devoted to the study of academic subjects of college entrance focus. State surveys in Maryland and in New York in 1939 disclosed that 63 per cent and 61 per cent, respectively, of the time of the youth of these states were spent in college entrance classes.

The defense of this type of secondary education has traditionally been that such work is essential or at least highly desirable for the successful pursuit of college courses. Space does not permit a consideration of the effects of such a program on the development of personal, social, and vocational competence of the 80 per cent of American youth who do not go on to college or on that of the 95 per cent who do not graduate. But the assumption that college success depends upon the study of certain prescribed high school courses for

certain lengths of time has been seriously challenged by a number of investigations. The data from these investigations are pertinent to the present discussion.

FACTORS RELATED TO SUCCESS IN COLLEGE

College entrance requirements have not changed greatly in the past twenty years. Twenty years ago the average number of subjects required for college entrance was 10; now it is about 9.4. Neither has the selection of the required courses changed materially.

Success in such prescribed courses has not been the only basis for college entrance. Subject examinations, batteries of standard tests, and aptitude tests have also been used. On an experimental basis comprehensive reports from the secondary schools have been used. Statistical studies by college and secondary school research workers have been carried on. David Segel's analysis, *Prediction of Success in College,* [2] was published in 1934.

The average correlations, shown by a large number of studies, between college scholarship and certain other factors are as follows:

Mental test results	.44
General achievement tests	.55
Tests of specific traits and aptitudes	.37
Average high school marks	.55

Obviously, these correlations are not sufficiently high for sound group analysis and are impossibly low for individual selection and guidance.

The average correlation between college success in mathematics or science and scores on general mental tests is .36; between such success and general achievement tests, .32; and between such success and specific aptitude tests, .45. Clearly, none of these correlations is of much worth in predicting success of groups, and none is of any value in predicting individual success.

Other correlations have been determined. For example, the average correlation between college success in beginning chemistry and teachers' marks in high school chemistry and in any other science, combined with scores on intelligence tests, is only .53.

It appears clear from these studies that college success in certain subjects and in general depends upon many other factors than success in a particular pattern of courses or achievement in high school work.

The use of composite groups of data against college success has materially increased the correlations. For example, Segel plotted the combination of average high school marks, a group intelligence test, and a comprehensive English test against college success and found a correlation of .81. This was the highest correlation found. The second highest pattern was found in a combination of average high school marks, a group intelligence test, and a study performance test; the correlation with college success was .75. Note the interesting point involved. These correlations (which used any combination of high school marks together with intelligence test results and results on tests of verbal ability) indicate that college success depends upon an individual's total ability demonstrated in a high school situation—not upon specific subject or test scores. In other words, these seem to indicate that if a young person wants to continue his education at a college or university he should have reasonably good ability as demonstrated by general high school success, he should have good reading comprehension and verbal ability, and he should be able to study effectively.

The data summarized represent the chief findings of nearly 150 studies. They appear to show rather clearly that college success is "neither predicted nor prepared for by study in a limited number of prescribed subjects. The assumption that a specific pattern of high school subjects should be pursued for college entrance cannot be supported by these statistical studies." (Quotation from Leonard.)

RESULTS OF THE EIGHT-YEAR STUDY

In 1942 the Commission on the Relation of Secondary Schools and Colleges of the Progressive Education Association published reports [3, 4] of its highly significant study of secondary school–college relationships. The study covered a time span of eight years and involved several thousand youth in thirty secondary schools and about 300 colleges in the United States. Of particular interest was the intensive study made of a group of 1,475 students from experimental high schools (schools in which the usual college entrance requirements were experimentally abandoned) who were carefully matched with an equal number of students entering the colleges from conventional high schools.

A committee of faculty members from the colleges drew up a list of criteria by which to judge college success. On the basis of these criteria the paired students were studied. The results indicated that the graduates of the experimental high schools:

(1) Earned a slightly higher total grade average in college
(2) Earned higher grade averages in all subject fields except the foreign languages
(3) Specialized in the same academic fields as did the comparison students
(4) Received slightly more academic honors in each year
(5) Were more often judged to have a high degree of intellectual curiosity and drive
(6) Were more often judged to be precise, systematic, and objective in their thinking
(7) Were more often judged to have developed a clear understanding of what they were in college for—especially during the first two years of college
(8) Earned in each year a higher percentage of nonacademic honors
(9) Had somewhat better orientation toward the choice of a vocation
(10) Demonstrated a more active concern for what was going on in the world

Other results were obtained, in all of which the experimental group (not subject in high school to the necessity of taking the usual college-preparatory courses) were equal or superior to the group from the conventional schools.

In commenting on the study, the college staff stated:

"If the proof of the pudding lies in these groups, and a good part of it does, then it follows that the colleges got from these most experimental schools a higher proportion of sound, effective college material than they did from the more conventional schools in similar environments. If colleges want students of sound scholarship with vital interest, students who have developed effective and objective habits of thinking, and who yet maintain a healthy orientation toward their fellows, then they will encourage the already obvious trend away from restrictions which tend to inhibit departures or deviations from the conventional curriculum patterns." [4, p. 113]

It is particularly interesting to note that the graduates from the schools that departed most radically from conventional college-preparatory curricula were, when considered as a separate group, even more able in college on the basis of the several criteria developed, including the criterion of academic competence.

RESPONSIBILITY OF THE HIGH SCHOOL SCIENCE TEACHER

What, then, is the responsibility of secondary school educators to the youth who will go on to higher education in the colleges and universities of the country? What is the responsibility of the science teacher?

First, he must recognize that the college-preparatory student, like every student, needs vital contacts with those aspects of science content and experiences which will materially assist his development as a person. All youth should develop optimum health, consumer abilities, and the many other aspects of knowledge, attitudes, and skills conducive to a rich and satisfying personal life and ability as a citizen of a democracy. The student who goes to college is no exception.

Second, the high school science teacher must offer additional experiences and content in the fields of science which may be taken on an elective basis, under guidance, by those who have a vocational in-

terest in furthering their knowledge of science on the college level. The pattern that such courses should take has yet to be worked out. There is no reliable basis on which to assume that any particular content and experiences have superiority over others. A content analysis of beginning courses in sciences at the college level should be made, and a purposeful sequence of content and experiences developed on the high school level for those youth who plan to go to college. From such an analysis it does not necessarily follow that the high school should undertake to offer a watered version of college work. The advantages of a cyclical plan of content and experiences should be explored and checked experimentally. The hypothesis that the development of a certain set of study techniques and unit skills and the development of perspective in the fields of science are most conducive to success in college science work should not be ignored.

—R. W. B.

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RESEARCH DEPARTMENT

A SURVEY OF RESEARCH STUDIES DEALING WITH THE ELEMENTS OF SCIENTIFIC METHOD AS OBJECTIVES OF INSTRUCTION IN SCIENCE

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SCIENCE as we know it today is essentially an organized body of knowledge coordinated and systematized within the frame of reference of certain general truths or laws recognizable in the phenomena of the physical or material world. This knowledge has been accumulated through the efforts of many generations of men who observed accurately, measured with care, experimented in many cases, and in the end recorded their findings for the benefit of those who were to follow. When this resulting fund of knowledge is refined and its significant meanings expressed in the form of *scientific principles* or generalizations from many facts, it becomes the basis for modern man's insight into the nature of his environment, the key to his control over that environment, and hence one of the most important aspects of our cultural heritage.

In the opinion of many people, however, the most valuable product of the labors of scientific men has not been the mass of knowledge thus accumulated but the method of inquiry developed, which in the

* The opinions and assertions contained herein are the private ones of the writer and are not to be construed as official or reflecting the views of the Navy Department or the naval service at large.

last few centuries has so greatly accelerated and enhanced the scope of scientific discoveries. This general procedure of efficient inquiry or of problem-solving has come to be known as *scientific method*. Its use implies certain attitudes of mind which seem to characterize those men who habitually employ it, habits of mind now referred to as *scientific attitudes*.

Much has been written by laymen and educators alike in favor of attempting to teach high-school and college students the use of scientific method, but until the last decade or so, very little research has been done to determine the nature of that method. This backwardness is somewhat surprising in view of the progress made in other fields of educational research. However, two factors have tended to retard and confuse the work of defining the scientific method. First, there has been a reluctance on the part of educational research workers to undertake to define in any detail the steps in a method of inquiry or problem-solving which depends so definitely for its determination upon the nature of the problem concerned. Second, there has been a common tendency among research workers and writers to confuse the elements of scientific method with the scientific attitudes, a tendency which still persists widely. Yet, in spite of these difficulties, progress has been made as is shown by reference to the studies summarized below.

In 1910, Dewey [1] published his famous philosophical treatise on *How We Think*, an analysis of the steps generally taken in reflective thinking. This analysis was not actually based upon any sort of objective research in current conceptions of the processes of reflective thinking, but instead represented Dewey's own introspective interpretation of the process. Some controversy arose subsequently as to the validity of Dewey's analysis; indeed it has been maintained by some that the title of the treatise might better have been "How *Dewey* Thinks." Nevertheless, more recent studies have seemed to substantiate Dewey's interpretation, at least in so far as the process of abstract thinking in problem-solving without benefit of experimentation is concerned.

Analysis of Scientific Method

Pioneering work in the actual analysis of the scientific method was done in 1928, when Downing [2] prepared a scholarly study of the elements of scientific thinking and devised his original "Test of Scientific Thinking," based upon the results of the analysis and designed for use at the secondary-school level. A careful examination of the elements resulting from this analysis indicates, however, that not all were strictly elements of method. Since Downing chose to stress the *safeguards* of scientific thinking, it was probably inevitable that many scientific attitudes should have been included in the list as well as elements of method. Perhaps this failure to distinguish between method and attitudes has helped to confuse subsequent research workers somewhat, and to prevent the earlier issuance of a clear-cut definition of the scientific method.

In 1933, Weller [3] attempted to determine whether "desirable attitudes and skills in problem solving," and some elimination of superstitions can be effected in elementary-school pupils through instructional procedures. For this purpose, she prepared three pairs of tests, the second pair of which consisted of twenty-one multiple-response items "constructed so that the first question of each set attempted to measure observation, the second a conclusion drawn, and the third a proof or possible verification of the conclusions drawn." Three sixth-grade classes totalling approximately 115 children constituted the experimental group, in which desirable attitudes and techniques of problem-solving were stressed and erroneous conceptions and superstitions were deliberately brought up and discussed. In the words of the in-

vestigator, "one method of scientific thinking, that is, observation of much data, drawing a conclusion from it, and attempting to verify this conclusion, was practiced, using simple problems of the children." In the other three classes of comparable size (the control), only "factual items" were discussed.

The scores of thirty members of the experimental group were compared with those of thirty members of the control group, the two selected groups having been equated on the bases of intelligence quotients and reading test scores. After computing the critical ratio from the scores of the two equated groups on the test on techniques, the investigator concluded that "the material of elementary science provides the means of developing desirable attitudes and skills in problem solving, if attention is focused on this aim." This study is significant in that it is the first in which a simple but definite technique of scientific thinking was taught experimentally as a means of gaining skill in problem-solving.

The first list of the elements of scientific method as distinct from scientific attitudes was published in 1934 by Curtis [4] who informally analyzed incidents in the history of science in which the steps by which scientists arrived at their most important discoveries were described in detail. His analysis revealed the following techniques which seemed to be definitely and characteristically scientific methods as distinct from scientific attitudes:

Locating problems
Making hypotheses, or generalizations, from given facts or from observations
Recognizing errors and defects in conditions or experiments described
Evaluating data or procedures
Evaluating conclusions in the light of the facts or observations upon which they are based
Planning and making new observations to find out whether certain conclusions are sound
Making inferences from facts and observations
Inventing check experiments
Isolating the experimental factor
Using controls

Curtis' analysis was obviously not intended as a thorough-going attack upon the problem of determining the scientific methods in complete detail; it was clearly intended merely to indicate some of the most evident and unquestionable elements of scientific method and to exemplify each by references to certain articles published as a series in *School Science and Mathematics*, entitled "Teaching Scientific Methods." Although his article does not include this information, Curtis' list of elements of scientific method was validated by submitting it to twelve teachers of pure science on the Faculty of the University of Michigan, all of whom approved of the list without objection.

SKILLS IN USING SCIENTIFIC METHOD

Another step forward in determining the elements of scientific method was taken in 1936 when, in connection with his study of scientific attitudes, Crowell [5] drew up and evaluated a list of skills necessary in using the scientific method. As a means of preparing an initial list, the investigator surveyed a large portion of the available literature to find out what the authors of books and magazine articles on philosophy, logic, science education, and science measurement, considered to be important mental qualities for those persons who would employ the scientific method. As a result of this research, a list of twenty-nine attitudes and twenty-five skills was compiled. These attitudes and skills were then incorporated in a form of questionnaire and submitted to more than one hundred science teachers for checking. Using the data to be found in the sixty-two questionnaires which were returned, the investigator then made up a list of the attitudes and skills, ranking them in the order of descending relative importance as determined by the respective percentages of judges who evaluated them as important.

Crowell's list of the skills essential to the scientific method appeared as follows:

Observing accurately
Recording observations accurately and in an orderly fashion
Forming independent judgments based on facts
Distinguishing between fact and theory
Picking out pertinent elements from a complex situation
Recognizing errors and defects in conditions and processes
Evaluating conclusions in the light of facts or observations on which they are based
Isolating the experimental factor
Forming sound judgments concerning adequacy of data
Synthesizing, or putting together, separate facts to form a conclusion
Gathering data systematically
Planning an experiment to determine whether or not a proposed hypothesis is true
Evaluating data or procedures
Recognizing omissions or deficiencies in situations
Profiting from worth-while criticism
Forming a reasonable generalization
Arranging and classifying data in sequence and making conclusions obvious
Applying general principles to new and concrete situations
Recalling selectively items essential to a problem
Locating problems
Disregarding irrelevant facts
Directing imagination into new and worthwhile channels
Using the scientific instruments common in the laboratory

It should be pointed out that Crowell made no pretense of studying the procedures of the scientific method, nor even of defining the term "scientific method." He wrote:

> The present study is concerned not so much with the definition of the term as with certain attitudes and skills associated with the scientific method. . . . The steps or procedures which are employed in the actual working out of a problem are of only incidental importance to us at this time.

Although he defined a "skill" as a *definite way of acting,* it is apparent that he did not wish to submit a plan for the over-all problem-solving technique involved when one organizes and carries out an attack upon a problem, that is, when these "ways of acting" are employed for a purpose. Yet, the *procedure* by which the solution of a problem is undertaken is of paramount importance in every case, and is well worth careful study despite the obvious difficulties involved in generalizing upon a problem-solving method which is so definitely dependent upon specific cases for its definition.

RECENT WORK

Although the writings of Stiles [6] on the subject of the scientific method are not based upon any formal research in the field, they should be mentioned at this point as being both earnest and enlightened discussions of the nature and use of scientific method.

In 1945, Keeslar [7] prepared an original list of the elements of scientific method, based upon a survey of the literature on the subject of scientific method. This list was submitted in questionnaire form for validation by the expert opinion of twenty-two research scientists of the University of Michigan staff. The various evaluations given by the judges to each element in the questionnaire were tabulated, and a relative numerical value on a 200-point scale was assigned to each item by means of a special formula designed for that purpose. Then a reduction of the total number of elements was effected by arbitrarily eliminating twelve minor elements which fell below the level of the 170th point on the 200-point scale. The forty-two items remaining were condensed in wording and reorganized to form a final list consisting of ten major and seventeen minor elements of scientific method, set forth in the order in which these might logically be expected to occur in the solution of any scientific problem of such a nature as to involve all ten major steps. These major and minor elements were thoroughly checked for ambiguity of expression and errors of omission by three specialists in the teaching of science. The abbreviated list of the elements of scientific method appeared in the following form:

I. *Sensing a problem and deciding to try to find the answer to it*
II. *Defining the problem*
  Stating the problem in words
  Analyzing the problem into its essential factors
III. *Studying the situation for all facts and clues bearing upon the problem*
  Drawing upon past experiences, both personal and those reported in literature, for possible explanations or generalizations to account for the phenomena observed
IV. *Making the best tentative explanations or hypotheses as to the possible solution of the problem*
  Recognizing the assumptions which must be made if one goes beyond the known facts in formulating a hypothesis
V. *Selecting the most likely hypothesis*
VI. *Inventing and carefully planning one or more experiments to test the hypothesis, isolating the experimental factor wherever possible by using a control*
  Deciding upon the kinds of evidence which should be collected
  Choosing reliable methods of collecting the evidence
  Refining measuring instruments to the degree warranted by the nature of the problem
  Practicing to gain skill in manipulation in order to secure accurate results
VII. *Testing the hypothesis by carrying out the experiment with great care and accuracy*
  Preventing as far as possible all uncontrolled variations in the conditions which might affect the results
  Making quantitative measurements of experimental results and estimating the probable error of such measurements
  Recording the results, adhering strictly to standard definitions and usage of scientific terms
  Organizing the pertinent data so that they may be studied and summarized
VIII. *Running check experiments involving the same experimental factor to verify the results secured in the original experiment*
  Studying the conditions of the experiment in order to detect any omissions, defects, or errors, particularly those errors which might have been introduced in the experimental results by coincidence or chance
  Recognizing and, if possible, checking further the validity of the assumptions involved in setting up the experiment
IX. *Drawing a conclusion*
  Arriving at a solution to the problem based on an honest, unbiased appraisal of the data
  Suspending judgment when results are not conclusive
  Calling attention in the conclusion to those basic assumptions which it has been necessary to maintain throughout the procedure
X. *Making inferences based on this conclusion when facing new situations in which the same factors are operating*

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6. Stiles, Karl A. "What is the Scientific Method?" *Bios* 13:13–20, March, 1942.
7. Keeslar, Oreon. *Contributions of Instructional Films to the Teaching of High School Science.* Unpublished doctoral dissertation, University of Michigan, 1945. Pp. 79–146.

RECENT BOOKS AND ARTICLES

BOOK REVIEWS

CAUDLE, FREDERICK L. *Workbook in Elementary Meteorology.* New York: McGraw-Hill Book Company, 1945. 191 p. $1.24.

This workbook was prepared to meet the need of students in elementary meteorology classes for exercises in weather applied to aviation.

It includes 44 units covering the usual topics presented in ground school and pre-flight meteorology courses. Several features are worth noting. Each unit contains text material, references, and one or more exercises in the form of graphs, maps, tables, and questions. Some units are profusely illustrated. The 44 units are divided into four sections at the end of each of which appears a short-answer test of 25 items for summary and review purposes. An appendix of useful meteorological tables, a glossary of common meteorological terms, and an index complete the book. Pages are perforated so that units may be taken up in any order desired.

The material is well organized, authentic, and up to date. Air-mass analysis, stability, fronts, hazards, map interpretation, and weather forecasting are treated in the modern manner. Frederick L. Caudle is a United States Weather Bureau Meteorologist, formerly a director and instructor in the Civilian Pilot Training Program at the University of Wisconsin, and a graduate of the United States Naval Academy. He is now at the State Teachers College, Oshkosh, Wisconsin.

The factual material at the beginning of every unit is too sketchy for the author to contend, as he does, that this workbook may serve as a basic text. Nine lines are too inadequate for a satisfactory treatment of Weather Elements and Instruments. Since at least 32 of the units suggest for reference, Elements of Meteorology, of which Caudle is one of the authors, it may have been more desirable to state that the workbook should accompany that textbook. One wonders why certain excellent textbooks and periodicals are not suggested for reference purposes. One questions the author's interrupting the continuity of the units on station models and international weather code with one on hourly sequence weather reports.

The workbook, however, is one of the best in its field. It is definitely not the "cookbook" type, for it demands much creative work by the student. An earnest attempt has been made to emphasize scientific principles as well as applications. But it is only fair to point out that, in a number of instances, scientific accuracy has been sacrificed to brevity; for example, in the determination of the heat of fusion of ice, no account is taken of the heat lost by the container. This is characteristic of workbooks and should not detract from the very excellent standing of the book.

Today, when surveys reveal that a contributing factor to the majority of airplane accidents is inadequate knowledge of weather science, Caudle's excellent *Workbook in Elementary Meteorology,* geared to twentieth century teaching methods, is invaluable to the aviation student.

J. FELDMAN

Proceedings of the Eighty-Second Annual Meeting of the National Education Association. Washington, the Association, 1944. 440 p. $3.00.

Those who are interested in the progress of education in the United States will want to read this report of the National Education Association. Addresses given before the Representative Assembly at Pittsburgh, minutes of business meetings, and reports of departments, officers, and committees, are included.

—ROY V. MANEVAL

RUSSELL, JAMES E. *Heredity in Dairy Cattle.* Peterborough, N. H.: American Guernsey Cattle Club, 1944, 135 p. $2.50.

In this book the Dean Emeritus of Teachers College summarizes what he has learned about scientific discoveries in genetics and illustrates the fundamental principles of heredity from the practice of successful breeders. Underlying this treatise is a philosophical viewpoint rarely if ever found in books of this kind. This practical philosophy makes the book an excellent one for the layman. Not only is it an excellent reference for 4H and FAA dairy clubs, but high school biology students and science teachers will find it most useful. Needless to say few similar books are written in as delightful a literary style.

—C. M. P.

PANTH, BHOLA D. *Consider the Calendar.* New York: Bureau of Publications, Teachers College, Columbia University, 1944. 138 p. $1.25.

This is a publication of the Bureau of Educational Research in Science, Teachers College. It gives evidence of much detailed and carefully planned research and editing. It is an excellent summary of the various time schemes used in the past, the origins and background of our present calendar, its defects and disadvantages, and some of the advantages and defects of proposed new calendars.

—C. M. P.

BUSH, VANNEVAR. *Science the Endless Frontier.* Washington: United States Government Printing Office, 1945. 184 p.

This is a report to the President by the Director of the Office of Scientific Research and Development. Few scientific reports, it may conservatively be said, have been as challenging or have carried the possibilities of so vitally affecting the lives of every American. Should the recommendations in this report be fully carried out (and there is a very strong possibility they will be), the consequences would not only affect the individual, social, and economic life of every American but would touch every group on earth.

Director Bush points out the wartime deficit in individuals trained to take up scientific work. Science is a proper concern of the government. Federal support is vital for any effective, coordinated program of research. However, freedom of inquiry must be preserved. Broad areas of proposed scientific development include those of war against disease, science and the public welfare, renewal of scientific talent, publications, scientific reconversion.

A National Research Foundation is proposed with five suggested divisions: (1) Medical Research, (2) Natural Resources, (3) National Defense, (4) Scientific Personnel and Education, and (5) Publications and Scientific Collaboration. Several possible functions are listed. A budget of 33 million dollars is proposed for the first year and one of 123 million dollars for the fifth year, at which point the budget should be fairly well stabilized.

About 80 per cent of the volume consists of reports of four committees: Medical Advisory Committee, Committee on Science and Public Welfare, Committee on Discovery and Development of Scientific Talent, and Committee on Publication of Scientific Information.

—C. M. P.

HEADQUARTERS STAFF, AMERICAN RADIO RELAY LEAGUE. *The Radio Amateur's Handbook (Twenty-Second Edition).* West Hartford, Conn.: American Radio Relay League, Inc., 1945. 728 p. $1.00.

This standard manual of amateur radio communication has been revised, redesigned, and restyled in the light of wartime and postwar needs, so that it may serve as a radio construction manual and training textbook for class or home study. The volume includes a twelve-page topical index in addition to a catalog section. There are some 1,200 illustrations, 133 charts and tables, and 240 basic formulas. It is the largest handbook produced.

This 1945 edition is divided into three main parts plus an introductory section. The ten chapters in the section on equipment construction contain practical information on the design and construction of all types of reliable amateur communication equipment. Treatises on amateur radio and radio operating are included in the section on general information.

—GRETA OPPE

HOWARD, FREDERICK THOMAS. *Complexity of Mental Processes in Science Teaching.* New York: Bureau of Publications, Teachers College, Columbia University, 1943. 54 p. $1.75.

This doctoral study reports on investigation of the nature of the relationship between ability to recall specific information and ability to perform more complex operations. The author found no report of a direct study of item complexity. A few related studies are briefly reviewed.

The cooperative General Science Test for college students, Form 1937, which was used, was judged to meet the following criteria: The test should be (1) in the investigator's field of specialization, (2) of satisfactory reliability, (3) composed of items apparently varying in complexity, (4) composed of items of a uniform type, (5) generalized in content, (6) widely used, and (7) one for which testing results are available. Six judges rated the 180 items of the test as to complexity. Five subtests varying in complexity were constructed. The tested population consisted of students from six representative colleges who took the test and rated the items. The investigator found that the factor accounting for the greatest variance (64 per cent) in the test scores was "whatever makes for science achievement." The second most important factor was an intellectual factor.

The writer concludes that the items of an objective test, commonly identified as an informational test, can be reliably ($r = .92$) placed from the most specific to the most complex, from the simple memory items to those requiring a considerable degree of association and integration. The study did not show that more complex items are measures of intelligence. The data lend little support to the thesis that the ability to organize and use facts, to make applications, is of a different order from the ability to recall specific facts. Organizing ability in a field of knowledge appears indistinguishable from extent of information in that field. There does not appear to be any large group of fact-getters who are unable to make use of these facts.

—C.M.P.

WOOD, L. N. *Raymond L. Ditmars, His Exciting Career with Reptiles, Animals and Insects.* New York: Julian Messner, Inc., 1944. 272 p. $2.50.

What boy has not enjoyed carrying around snakes and frogs in his pockets? Raymond L. Ditmars was that kind of boy, but was able to turn his hobby of collecting into a profession. This story is a very human account of this great American scientist.

Young people, and adults too, will be amused over the early chapters in which the author shows Raymond Ditmars as a likeable boy, quietly doing his regular work, but vitally in-

terested in collecting insects and snakes. Some of his collecting activities were quite embarrassing to his parents.

Raymond Ditmars' hobby led to a career as a scientist, lecturer, traveler, writer, and herpetologist. He was connected with the New York Zoological Park for over fifty years. His travels took him all over the world in seeking new specimens. His many books on natural science are well known and his research in antivenomous serum contributed materially to the founding and development of the Antivenin Institute.

Biology and general science teachers will want copies of this book in their room libraries. It would be a valuable addition to the science shelves of any library.

—ROY V. MANEVAL.

CENTRAL YMCA COLLEGE. *A B C's of Scapegoating.* Chicago: Central YMCA College, 1944. 72 p. $0.25.

Scapegoating has been called the great human pastime. This pamphlet defines scapegoating, motives, types, forms, dangers, and methods of combatting. There is a foreword by Professor Gordon W. Allport of Harvard University.

—C.M.P.

FLIMLIN, GEORGE E. *Science Audio-Visual and Teaching Aids.* 1943. 43 p. 75c. HEIMERS, LILI. *Flying and Weather Audio-Visual and Teaching Aids.* 1942. 13 p. 50c. HILDEBRANDT, E. H. C. *Mathematics Visual and Teaching Aids.* 1942. 15 p. 25c. Upper Montclair, N. J.: New Jersey State Teachers College, Visual Aids Service.

The above three publications in mimeographed form are part of a series of such publications relating to various subject-matter fields. Remittance by check or money order payable to the college must accompany each order.

Sources of charts, maps, exhibits, films, slides, publications, pictures, recordings, etc., are listed according to subject matter, and are also indexed. Most materials listed are free or inexpensive.

—C.M.P.

ZIM, HERBERT S. *Rockets and Jets.* New York: Harcourt, Brace and Company, 1945. x+326 p., illus. $3.00.

In the foreword Dr. Zim writes, "The difficulty in telling the story of rockets and jet propulsion is that the past abounds in meager reports of secret experiments; the present is cloaked in military secrecy; and the future is an area of vague speculation." The truth of this is realized again and again in the book's twenty-two chapters.

On the other hand, your reviewer could not help but wonder more and more as he read at the wealth of material that the author's researches had uncovered. The bringing together of these materials provides ample justification for the writing of such a book.

A notable feature is the clear and interesting manner in which the underlying science ideas are explained. Chapter II is devoted to the "Basic Principles" of rocketry. As you might expect, Newton's third law is a main item here, but such matters as combustion, exhaust velocity, streamlining, gravity, and friction are considered. Subsequent chapters also deal with basic principles, but in a broader sense.

In chapters called "Escape from the Earth," "The Goals of Interplanetary Rockets," and "Interplanetary Problems," you are confronted with a most challenging combination of scientific fact and imaginative speculation, each, however, carefully labeled. Incidentally, the author weaves into his narrative an extremely painless lesson in the elementary astronomy which relates to the solar system. Readers will no doubt be intrigued with the reasoning that has gone into the plotting of the most efficient routes for interplanetary travel and to learn why the trip to Venus and back would likely be an affair of 762 days, to Mars and back a 971-day affair, etc. As implied here, the author has woven a great deal of science about what otherwise might have been a very limited though timely subject.

The later chapters deal with very recent developments in aviation in regard to jet motors and gas turbines; also with the V-1 bomb and the V-2 rocket. Even here the author has been able to introduce a considerable amount of interesting material. He sheds light upon our own experimentation with these weapons during the present war, as well as upon the efforts of our enemies. The final chapter gives what appears to be a very sane appraisal of the future of rockets.

The book is well illustrated with drawings and photographs and is attractive in format. Its simplicity and non-technical nature make it very readable, regardless of one's training in science.

—HARRY H. WILLIAMS.

RATCLIFF, J. D. *Yellow Magic: The Story of Penicillin.* New York: Random House, 1945. xv+170 p., 10 figs. $2.00.

This book is interesting and well written, and presents the story of penicillin—its discovery, the gradual development of knowledge of its medical uses and limitations, and its present status. It is written in non-technical language which makes it excellent reading for the layman. Many scientists who are not specialists in this field will want to read this book because it is an excellent summary of the work with penicillin to the time of publication. There is doubtless considerable chemical work of a confidential nature which has not yet been disclosed.

Aside from the great present interest in penicillin, the book is worth reading as an excellent illustration of the scientific method and gradual development of knowledge, of how important applications may depend on long, patient work to account for observations which at first seemed rather insignificant.

For once, the commercial drug and pharma-

ceutical concerns get their due credit for the important part they played in helping to develop essential methods of mass production in the early stages.

—DONALD E. LANCEFIELD.

LYNN, ELDIN V. *Organic Chemistry.* Philadelphia: Lea and Febiger, 1945. 355 p. $4.50.

This is a second edition of an organic chemistry textbook designed especially for medical and pharmaceutical application. The author is professor of chemistry at Massachusetts College of Pharmacy, Boston. The introduction painstakingly takes care of the scope of organic chemistry in relation to the basic principles a student of pharmacy must know. There are 44 chapters, the first dealing with the hydrocarbons and the last with dyes, glycosides and resins, proteins and enzymes. Review questions accompany the chapters and the book is carefully indexed.

—GRETA OPPE

WERTHEIM, E. *Textbook of Organic Chemistry, Second Edition.* Philadelphia: The Blakiston Company, 1945. 867 p. $4.00.

In this second edition, the author has included new tables, charts, illustrations of molecular models, and additional review questions and numerical problems. The text material is well organized and clearly written.

—ROY V. MANEVAL

DEMING, H. G. AND ARENSON, S. B. *Exercises in General Chemistry and Qualitative Analysis, Fifth Edition.* New York: John Wiley and Sons, Inc., 1945. 298 p.

This edition includes a new selection of experimental exercises, intended to illustrate the most important principles in the application of chemistry in industry. A few exercises are planned primarily for students of engineering and home economics. In the qualitative analysis section of the book a number of improved procedures have been introduced, including the use of organic reagents for the detection of inorganic cations and anions. The instructions for each exercise are clearly worded, and the book as a whole is well organized.

—ROY V. MANEVAL

SCHRODINGER, ERWIN. *What Is Life?* New York: The Macmillan Company, 1945. 91 p. $1.75.

Men in every age and in all ranks of life have asked the question that is the title of this book, "What Is Life?" Always unanswerable in a completely satisfying way, its discussion and contemplation are, and long promise to be, intriguing. And a discussion by a noted physicist adds to the zest. Not an easy popularization, there is nothing in this book beyond the comprehension of the informed man.

Dr. Schrodinger shows that the working of an organism follows exact physical laws. Heredity and mutations are discussed on the basis of physical laws. The Brownian movement, disintegration of radioactive substances, the quantum theory, and Delbruck's model are used in explaining the behavior of organisms and showing that there is order in apparent disorder.

The author maintains that there are two methods of producing orderliness: the "statistical mechanism," which produces "order from disorder," and a method based upon the quantum theory, producing "order from order." The latter inevitably leads to the question, Where and how do determinism and free will come into the picture of man's activity? Dr. Schrodinger discusses this problem in the epilogue. His conclusions are challenging to those who have followed his reasoning and to others interested in the philosophical and religious questions of determinism, free will, the soul, and future personal existence.

—C. M. P.

ABSTRACTS

ELIASSEN, R. H. AND MARTIN, ROBERT L. "Pretraining Selection of Teachers During 1940–1943." *Journal of Educational Research* 38: 666–667. May, 1945.

Significant studies of the problem of selecting teachers are being made in Wisconsin, New York, and New Jersey. Institutions making a systematic study of the problem and experimenting with techniques of selections include the University of Syracuse, Milwaukee State Teachers College, Queens College, Wayne University, and Wilson Teachers College.

Some conclusions are: (1) Personality is the most important factor to be considered in predicting a teacher's success. (2) Teacher recruitment must begin in secondary schools. (3) There is need for more adequate criteria of teacher success. (4) Selective techniques have raised the proficiency level of teaching candidates above the average of non-teaching students. (5) Objective instruments of teacher evaluation are too artificial. Test constructors need to get closer to the scene of action. (6) Teaching is complex and a teacher must bring his whole self into teaching, thus making the problem of

prognosis very difficult. (7) The results of scientific studies of pretraining selection of teachers have been disappointing to date. (8) Subjective judgment and common sense must play an important role in the selection of teachers. (9) Most rejections are due to poor scholarship, personality defects, lack of culture, and faults in English usage. (10) It is easier to predict the success of women than of men.

—C. M. P.

PETERSON, SHAILER. "The Word-Dexterity Test, A Better Measure of College Aptitude." *Educational and Psychological Measurement* 4:307–313. Winter, 1944.

This article describes a measuring instrument which as an aptitude test compares favorably with examinations commonly given during Freshman Week. The test has been given at junior high school, senior high school, and college levels, and has proved itself a valuable predictor of school and course grades. The main objectives of the test are to determine to what extent the student knows the meaning of certain suffixes and prefixes in common use and whether he can transplant the meaning of a suffix or prefix found in one word, whose meaning is known, to another word in which the same suffix or prefix is found. —C. M. P.

FRENCH, WILL. "The Postwar High School Should be Purpose-Organized." *Teachers College Record* 46:403–412. April, 1945.

The author believes that one of the greatest needs of high school is reorganization and that this reorganization should be "purpose-organized." Purpose-organization would result in the following changes: (1) Under the immediate supervision of the principal would be four or five "coordinators," each representing a major purpose of secondary education which the school intended to stress. (2) The coordinators or coordinating committees would each study the school's work to see that everything possible was being done to achieve the major purposes of the school. (3) Courses of study would be developed in which content was evaluated in terms of its usefulness in achieving one of the major purposes with the students for whom the course of study was intended. (4) The requirements and electives under each of the school's curricula would be reconsidered in terms of the purposes of each curriculum for its students. (5) The registration of students for a new year would be under the supervision of the coordinators. (6) The practice of requiring students to secure a given number of credits in certain departments or subjects before graduation would be abandoned. (7) When the school's educational program is in the direct charge of coordinators who are responsible for the achievement of major purposes through that program, we may expect each of them to be concerned about evaluating the pupils' growth in terms of the purposes for which he as a coordinator is responsible. (8) A trend toward purpose-organization of secondary schools will modify programs for the education of teachers.

—C. M. P.

LORGE, IRVING. "Schooling Makes a Difference." *Teachers College Record* 46:483–492. May, 1945.

Few studies have shown the value of education for increased mastery of the abilities measured by intelligence tests. Dr. Lorge reports the retesting in 1941 of the intelligence of 131 men averaging 34 years of age, twenty years after they were tested for their mental abilities in the 8B classes of New York City public schools. The 131 subjects who took the retest were judged by carefully defined criteria to be a random sampling of the original group of 863.

Results of the study showed that the mental age had increased with increase in schooling. However, schooling did not convert men making the poorest scores in 1921 into the intellectual peers of the men who had then made the best scores and had received little additional schooling. The constancy of the IQ has been refuted and the effect of schooling upon scores made on mental tests seems proved.

—C. M. P.

STONE, CHARLES H. "Some Observations on the Teaching of Chemistry." *Journal of Chemical Education* 48:337–339. July, 1945.

Based on observations of numerous chemistry classes in many high schools, the author comes to the conclusion that the following faults are altogether too common among science teachers: (1) too much dependence upon the text, (2) failure to use demonstrations adequately or at all, (3) lack of resourcefulness, (4) failure to follow up the experiment (with similar materials or examples), (5) failure to enunciate a general principle, (6) failure to use practical tangibles in place of textbook intangibles, (7) too much teacher-telling, and (8) use of inane questions.

—C. M. P.

ELLIS, FRED E. "Improvements in the Teaching of Science." *The Clearing House* 19: 352–355. February, 1945.

This article is a plea for making science teaching more functional, more informal, more of a cooperative affair between pupil and teacher, more environmental, more concerned with emphasis upon scientific methods as habits of behavior rather than as attitudes, and greater use of tools of evaluation.

—C. M. P.

ENGSTROM, O. A. "Science Texts: Why They Put Pupils to Sleep." *The Clearing House* 19:439–442. March, 1945.

This article points out some of the failures of present-day science textbooks. Among other deficiencies, they lack up-to-date, relevant photographs, usable bibliographies, teacher aids, and suggestions for significant experiments and demonstrations. Too many so-called revisions are merely more recent copyright dates.

—C. M. P.

FURNAS, C. C. "The Storehouse of Civilization." *Journal of Chemical Education* 22: 179–183. April, 1945.

The problems of wise use and conservation of our natural resources are going to become more difficult in the future than they are at present, not only because of the great depletion that has already taken place, but because of greater use of these resources throughout the world. They will be solved by hard work—careful research by scientists, but there is a real danger that we will wait too long before we begin to look for the answers.

Possible sources of future power (after present reserves of oil and, later, of coal give out) include oil shales, alcohol, water power, and atomic energy. Eventually we must rely on the sun's rays as a source of all energy.

Metal supplies may be conserved by reuse of metals, use of lower grade materials, and substituting the more plentiful metals for those which are scarce.

Agriculture is the third great resource of our lives. Here we must solve two immediately pressing problems: (1) the lack of maintenance of fertility of the soil, and (2) mechanical erosion by wind and water.

—C. M. P.

WEAVER, ELBERT C. "Demons in Demonstrations." *Journal of Chemical Education* 22: 339–341. July, 1945.

The author discusses five demons in demonstrations: money, minutes (time), mystery, monotony, and muss.

—C. M. P.

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